anglianwater

Climate Change Adaptation Report January 2011

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1 Foreword

1.1 During the last decade climate change has steadily risen to the top of our agenda and since 2005 we have placed increasing importance on how we adapt our business to cope with the challenges of operating in a changing climate. We have come to the conclusion that successful adaptation for our business is reliant on a number of critical elements:

- the provision of science, interpretation and independent advice is crucial to ensuring that the United Kingdom (UK) continues to adapt successfully. The support that the UK Climate Impacts Programme (UKCIP) provided was invaluable in developing our understanding of the potential impacts.

- the tools that use the UKCIP data to quantify the risks to our assets and the methods that are used to understand the costs and benefits of proposed adaptation actions must not be static. They must continue to be refined using the best available data.

- outputs from risk assessments and the assumptions used in developing our business plans, must be agreed and recognised in the mechanism for setting price limits if adaptation actions are to be delivered on the ground.

1.2 This adaptation report has come at an opportune time, following on from the release of the UK Climate Projections 09 (UKCP09) and at the beginning of a new investment cycle. It has coincided with our review of the UKCP09 data and their implications for our business operations. This allows us to incorporate the reviews findings at the earliest stage of the next investment cycle and to ensure that changes to the regulatory framework can be considered, coastal defences are a case in point. If changes are made to the current mechanism for funding the management of these assets and third parties are required to make contributions then this must be reflected in how our price limits are set in the future.

1.3 We recognise that resilience is important in delivering successful adaptation and we are investing to enhance the flexibility of our networks, however it is our firm belief that we can not adapt in isolation. It is not enough to just physically adapt our assets, we must also work with our customers to help them understand the role that they can play, for example using our 'love every drop' campaign to encourage water efficiency. We must work with the other organisations in our region to understand our interdependencies and to overcome barriers to adaptation. We have demonstrated this in working with other water companies to report on the opportunities for water resource sharing in East Anglia. We must also contribute at the national level by participating in the development of the National Climate Change Risk Assessment, the National Adaptation Programme and sharing our experience of managing critical infrastructure resilience.

1.4 We have taken the implications of climate change extremely seriously and believe that we have a good understanding of what is required to adapt to the challenges. We have ensured that our management structure and planning processes have incorporated adaptation accordingly. Climate change is a challenge that we can hope to meet only in unison and we make our commitment to contribute to creating a successfully adapted UK.

Peter Simpson, Managing Director

2 Executive summary

1. Information on organisation	
Name of organisation	Anglian Water Services Limited
Organisation's functions, mission, aims, and objectives affected by the impacts of climate change	We supply water and wastewater services to more than six million domestic and business customers in the East of England and Hartlepool. We have an asset base of more than 6,900 water and wastewater assets and 81,100 kilometres of water and wastewater pipes[(1)]. Climate change has the potential to affect all areas of our operations. Coupled with regional growth projections it has been identified as the biggest risk facing our company in the long-term. Mitigating and adapting to climate change is a strategic priority in our 2007 Strategic Direction Statement (SDS).

2. Business preparedness before Direction to Report was issued	
Has your organisation previously assessed the risks from climate change?	We have been assessing the business risks posed by climate change for more than a decade, with particular relevance to water resource planning (see Figure 4.1 'Our climate change adaptation action'). A whole company climate change risk assessment was carried out in 2005. A review was initiated prior to the Direction to Report in response to UKCP09. This led to the creation of a new quantitative risk assessment in 2010. There have been interim reviews and project specific risk assessments such as those associated with our Asset Management Plan 5 (AMP5) Final Business Plan (FBP) submission.

1 Further detail can be seen on our website at www.anglianwater.co.uk

2. Business preparedness before Direction to Report was issued	
If so, how were these risks and any mitigating action incorporated into the operation of your organisation?	The key challenges of climate change and growth underpinned our approach to developing our 25 year strategic planning process. This has been used to generate our SDS, AMP5 FBP and the Water Resources Management Plan (WRMP). An agreed climate change methodology has been used to inform our WRMPs since 1993. Core to the identification and management of risk within our company is our Risk and Value (R and V) process. This is applied throughout our asset creation and delivery process. In 2010 we created a Climate Change Steering Group (CCSG) to better manage the risks and action plan for both our adaptation and mitigation workstreams. See Table 6.3 'Programme of measures key actions' for examples of our adaptation actions.

3. Identifying risks due to the impacts of climate change	
What evidence, methods, expertise and level of investment have been used when investigating the potential impacts of climate change?	The most important evidence we have used relates to the UKCIP02 and UKCP09 projections. We have also drawn on the associated tools, expertise and direct support of the staff at UKCIP. We and our business unit specialists have worked with the Meteorological Office, the Tyndall Centre, UKWIR and the Environment Agency (EA). These collaborations have developed generic qualitative climate change risk assessments and specific assessments for impacts on key activities. In addition to these projects, we were one of the first companies to appoint a full-time climate change advisor. This post has been key in co-ordinating education, research and action to embed climate change adaptation into our company. A significant number of hours from teams across our business have been used to support and deliver this, particularly our R and V, Innovation, Asset Management and Water and Wastewater Service teams.

4. Assessing risks	
How does your organisation quantify the impact and likelihood of risks occurring?	We undertook a qualitative risk assessment in 2005, using a standard likelihood and severity matrix, generated by business unit experts. This has been enhanced with the development of a quantitative risk assessment which uses financial values from our business risk assessment methodologies, climate change likelihood values from the UKCIP tools and thresholds from selected business unit experts. We are currently incorporating the outputs of this into our existing R and V process.

5. Uncertainties and assumptions	
What uncertainties have been identified in evaluating the risks due to climate change?	Dealing with uncertainty is key to dealing with climate change as the science and the projections are inherently uncertain. In addition, other uncertainties relate to: • understanding how to use the scenarios • the future of the regulatory landscape • confidence in how our activities will react to climate change • the impact of interdependencies on our operations, for example flood defences. If changes are made to the current mechanism for funding the management of these assets and third parties are required to make contributions then this must be reflected in how our price limits are set in the future. However these uncertainties are not preventing us from developing 'no regret' and 'low regret' adaptation actions to maintain services to our customers and protect the environment in our region (See Table 6.3 'Programme of measures key actions').
What assumptions have been made?	The assumptions we have made are highlighted within Section 8. Some of the more significant are: • UKCIP projections represent realistic futures • current regulatory regime will remain the same • figures and thresholds used in the risk tool are accurate pending future planned work.

6. Addressing current and future risks due to climate change - summary

Business function	Climate variable (e.g. Increase in temp)	Primary impact of climate variable (e.g. health)	Threshold(s) above which this will affect your organisation	Likelihood of threshold(s) being exceeded in the future and confidence in the assessment	Potential impacts on organisation and stakeholders	Proposed action to mitigate impact	Timescale over which risks are expected to materialise and action is planned
All	Climate change	See Table 5.1 'Our original risk assessment results'	Various	Top in company risk register	Inability to deliver statutory functions	Establish climate change team and corporate governance	Short-term
	Sea level rise	Coastal erosion and inundation	See Case Study 5	High	Temporary or permanent asset loss Property flooding	Internal analysis and input into Shoreline Management Plan (SMP) process	Medium to long-term
Wastewater treatment	Flooding	Site inundation	Table 7.2 'Climate change thresholds and their multipliers, from baseline to future'	Figure 7.11 'Risk scores of each consequence affecting individual WwTW'	Compliance risk Environmental effects	Flood prevention and protection	Short-term
	Increase in temperature	Process failure				Innovation research and design project	Medium-term
Biosolids treatment		Increased odour		Figure 7.5 'Risk scores of each consequence affecting individual STC'	Abatement notices	Review biosolids strategy	Short-term
Wastewater pumping	Extreme rainfall	Asset failure		Figure 7.4 'Risk scores of each consequence affecting individual SPS'	Property flooding	Investment to remove priority properties from risk register	
Sewerage		Sewer capacity exceeded	See Table 5.2 'Our AMP5 priorities'	Medium		Innovation and research and design project	

6. Addressing current and future risks due to climate change - summary

All water processes	Flooding	Site inundation	Table 7.2 'Climate change thresholds and their multipliers, from baseline to future'	See Figures 7.4 - 7.11	Supply interruption and contamination	Investment for flood prevention and protection	Short-term
Water treatment	Increase in temperature	Raw water quality deterioration		Figure 7.9 'Risk scores of each consequence affecting individual WTW'	Increased treatment costs	Innovation research and design project	Medium-term
Water resource	Precipitation and temperature changes	Water resource availability and demand changes	See WRMP10	See WRMP10	Changes in Deployable Output (DO) and demand impacts	Review WRMP	

7. Barriers to implementing adaptation programme	
What are the main barriers to implementing adaptive action?	Of the adaptation implementation barriers we have identified the four main ones are: • an absence of clear national guidance, for example design standards • a lack of nationally coordinated research • variability in customer acceptance of the need for adaptation • costs of adaptation not recognised in price limits and inherent difficulties in valuing loss of service. Overcoming these barriers will require many stakeholders to work together and we will work to achieve this through our 'love every drop' campaign. This is our commitment to put water at the heart of a new way of sustainable living and it is about: • helping people in our region to understand just how precious water really is • effectively managing the impacts of growth and climate change on our region • working with everyone who influences water use in our region • acting today while thinking for the long-term. These commitments are core to our company and will be implemented through the delivery of the actions detailed within this report and our programme of measures. This will enable us to develop 'no regret' and 'low regret' adaptation actions to maintain services to our customers and protect the environment in our region (see Table 6.3 'Programme of measures key actions').
Has the process of doing this assessment helped you identify any barriers to adaptation that do not lie under your control?	There are a number of barriers to adaptation over which we have little or no control: • the economic regulator's approach • reliance on flood defences maintained by third parties • engagement by key suppliers (especially energy) • spatial planning decisions. A wider discussion of these issues can be seen in Section 8.

8. Report and review	
How will the outcome of the adaptation programme be monitored and evaluated and what is the timetable for this?	The outcome of our adaptation programme is reported, monitored and evaluated at a number of levels within our company (see Figure 9.3 'Our monitoring and review cycle'). Business units will deliver individual projects (see Table 6.3 'Programme of measures key actions') and report progress to our CCSG. This will review progress, coordinate action and ensure that data is reported through the existing internal governance structures and external regulatory reporting mechanisms. Whilst the cyclical nature of our review process will ensure that all projects and their outputs are subject to continual review, the detailed timetable will be project specific.
How do you propose to monitor the thresholds above which impacts will pose a threat to your organisation (including the likelihood of these thresholds being exceeded and the scale of the potential impact)?	Our asset monitoring processes enable us to track trends in performance and to identify the causes of failure. This will allow us to monitor how assets are responding to climate change and to extrapolate the trends for business planning purposes, including developing adaptation actions as and when necessary (see Section 9). To further understand the impacts of climate change we intend to carry out research work to validate those thresholds that we have used in our risk assessment and to identify others as necessary.
How will the benefits of the programme be realised and how will this feed into the next risk assessment?	The benefits of our actions will be seen only over the long-term. However our company performance, right down to an asset level, is subject to a variety of continuous monitoring and review cycles (see Section 9). It is through these that the progress and effectiveness of our adaptation actions will be monitored and evaluated.
How have you incorporated flexibility into your approach?	All of our governance and monitoring systems are cyclical, incorporating review phases (see Section 9). This gives us the flexibility to respond to changes and make adaptation decisions at the appropriate time, over both the long and short-terms. This is aligned with the UKCIP adaptation review process.

9. Recognising opportunities	
What opportunities due to the effects of climate change and which the organisation can exploit have been identified?	Due to the nature of our business we have found limited opportunities directly associated with adaptation (see Section 10). However there are significant opportunities to deliver mitigation actions and to use the adaptation message to encourage beneficial behavioural change. This is driven through our 'love every drop' campaign where we state our intention to: • halve our embodied carbon in new assets we build by 2015 from a 2010 baseline • reduce our operational carbon emissions by 10% in real terms by 2015 from a 2010 baseline • have 80% of domestic customers using water meters by 2015 and make the link in our customers' minds between water, carbon and the environment.

10. Further comments / information	
Do you have any further information or comments which would inform Defra (e.g. Feedback on the process, the statutory guidance, evidence availability, issues when implementing adaptation programmes, challenges etc)?	The reporting power has been a useful tool in aiding our post-UKCP09 review of adaptation across the business. We believe we are well placed in our understanding of the impact of climate change on our operations and our ability to deliver the right adaptation measures, where investment has been approved (see Section 11). The technical support from UKCIP has been extremely helpful throughout the process and this type of independent advice is vital for the UK in continuing the practical application of the science of climate change. The information in the adaptation reports must be used to inform and develop the national and regional risk assessments and adaptation programmes if the knowledge gaps, barriers and interdependencies are to be identified and overcome.

3 Introduction

Key messages

1. We provide world-class water and wastewater services to 6.1 million domestic and business customers in the East of England and Hartlepool.
2. We have recognised climate change as a significant risk to our ability to provide these services.
3. In 2007, our SDS sealed our commitment to preparing for these challenges.
4. Adapting to climate change was a key theme in our FBP (2010 - 2015) and we are already delivering action.
5. This report demonstrates how we have embedded adaptation into our business planning processes.

Our business

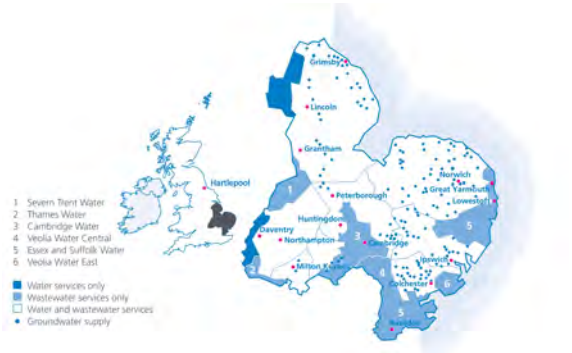
3.1 Our services are at the heart of every single family and community in our region. We provide safe drinking water and effective, efficient wastewater services. We borrow water from the environment, store it and treat it to world-class standards to supply safe drinking water to 4.3 million customers in towns and villages from Grimsby in the north east of our region to Milton Keynes at its south western tip.

3.2 Every day our customers flush around one billion litres of wastewater down toilets and drains into our wastewater network. The wastewater is collected, treated and returned to the environment through rivers and coastal outlets. Around 5.8 million domestic and commercial customers in our region rely on us to safeguard their health and protect the environment where we all live and work.

3.3 To deliver our vital service we own, maintain and operate:

- 6,900 water and wastewater assets
- 81,100 kilometres of water and wastewater pipes
- 18 reservoirs
- 224 groundwater sources.

Figure 3.1 Our operational region



Our region

3.4 Each region in the UK has its own distinguishing features. Our region covers 27,500 square kilometres, close to 20% of the area of England and Wales, and is defined by many characteristics. These are flat topography, low-lying soft rock coast, slow-flowing nutrient rich rivers, intensive agriculture, low rainfall and important sites for nature conservation, many of them wetlands.

Figure 3.2 SSSI in our region

3.5 Operating in a region which is typically low-lying and has a coastline approximately 1,238 kilometres long, brings a number of challenges, including a risk of flooding. Also with little help from gravity, we rely heavily on electricity to pump water and wastewater around the region.

3.6 Water moves slowly across our flat landscape and our river systems reflect this. These fragile river ecosystems can be easily damaged by pesticides and excess nutrients from fertilisers. Our Water Treatment Works (WTW) remove chemicals and pesticides that can enter watercourses from agricultural land. We remove more specific nutrients, such as phosphorus, at some of our Wastewater Treatment Works (WwTW).

3.7 Our region is the driest in the UK, with only two thirds of the average rainfall for England and Wales. In 2009-10 the total rainfall was only 613mm.

3.8 The land and reservoirs we own are home to internationally important wildlife habitats for hundreds of species including wildflowers, insects, birds and mammals. Our region also holds around 20% of England's Sites of Special Scientific Interest (SSSI) (see Figure 3.2 'SSSI in our region'). We have a responsibility towards these and many other environmentally designated sites requiring special care.

A changing climate in the East of England

3.9 In 2007 we stated in our SDS that climate change is one of the biggest risks to our business. We will need to continue to provide water and wastewater services in a changing and uncertain climate. The rate of change is uncertain, however the UKCIP02 and UKCP09 projections suggest it is very likely that we will have to accommodate higher average temperatures, wetter winters, drier summers, rising sea levels and more frequent extreme weather events. It is a particularly serious challenge in the East of England as the region is likely to be one of the most vulnerable to climate change.

3.10 The temperature rise and the potential reduction in summer rainfall could lead to fewer available water resources in the longer-term. As the driest region in the UK we must manage supply and demand carefully to meet one of our customers' most important priorities – a secure supply of drinking water.

3.11 Changes to the frequency and intensity of extreme storm events and rising sea levels could lead to an increased flood risk. Extreme storms and wetter winters have already caused localised flooding that threatens our wastewater network, floods customers' homes and has the potential to disable treatment works. We recognise the need to take action to meet the challenges to our assets, and our region's environment, posed by damage from flooding.

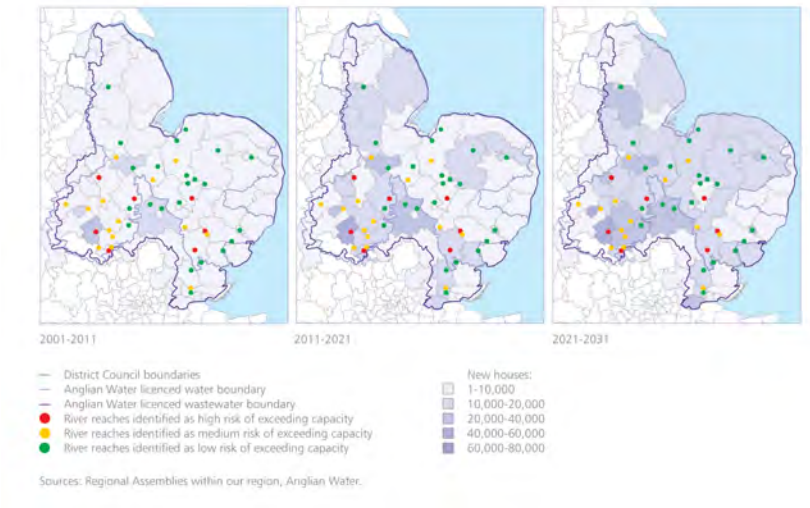
Growth

Figure 3.3 Climate change vulnerability

Source: Anglian Water.

3.12 Adding to the pressure from climate change are the growth plans for our region. We serve one of the fastest growing regions of the UK, with Government forecasts and plans suggesting that our region will be disproportionately affected by housing growth. The location of this growth (as shown in Figure 3.4 'Growth plans'), combined with an understanding of the changing climate is critical. These maps use the Local Authority level growth forecasts upon which the 'regional spatial strategies' were based. They also show which river reaches in our region are already close to the limits of their environmental capacity to receive flows of effluent. It can be seen that much of the growth is predicted in areas at risk of flooding and / or where rivers are close to capacity. Therefore part of developing adaptive capacity must be understanding and incorporating the implications of climate change for our business into the growth plans of the region.

Figure 3.4 Growth plans



Implications for our business

3.13 When most people consider the implications of climate change for the water industry, they usually think of the direct impact on future water resources. This is a significant consideration and is why we have been incorporating climate change projections into our water resources planning for more than a decade. With good forward planning, and with our customers using water wisely, water resources is not the most pressing issue over the short-term.

3.14 Climate change has many other implications for our business and we are seeking to explore and understand all of them. However this report will only examine the highest priority issues. For some of these it will also detail how adaptation actions have already had investment approved and are being implemented. Other actions will require further investigation or research, with progress monitored by our internal CCSG and the Board (as explained in Section 9).

Figure 3.5 Cromer storm surge 2007

3.15 Our key challenges from climate change are:

- protecting our vulnerable inland and coastal operational assets from flooding
- dealing with increased wastewater flows, while protecting the water environment in our region
- maintaining supplies of water to a growing population in drier, hotter summers
- planning for the great uncertainty associated with climate change.

To continue to maintain the current levels of service that our customers expect, in the face of growth and climate change, we will have to ensure that our business is flexible and able to adapt. For example:

- changing from pumping water into reservoirs when it is cheapest, to pumping it when it is available
- seeking to use alternative water management regimes like groundwater recharging and more sustainable drainage schemes
- making our water treatment and supply network more flexible and resilient.

Adaptation actions already underway

In our SDS, we stated that as a priority our climate change strategy must tackle the elements relating to extreme weather events. This would ensure that we could provide the resilience of our operations and assets that customers expect, and meet the challenge of climate change. To achieve this we needed to:

- adapt our operations and assets to the impacts of climate change and the effects of severe weather-related events
- provide alternative piped drinking water supplies to major centres of population, in the event of a catastrophic outage.

3.16 We committed to developing alternative supplies for Norwich and Peterborough and we have since invested an additional £40 million, beyond Ofwat's 2005 - 2010 Final Determination (FD), in schemes to improve the resilience of supply in these areas. We further committed to putting forward resilience business cases for other population centres and these were included in our FBP submission for the AMP5 period, 2010 - 2015. We were successful in securing approval for an investment of £2.3bn in our region over the next five years. This includes £5 million for flood protection of water treatment assets. A further £35.2 million will increase resilience in our water treatment and supply network benefiting 776,586 customers.

3.17 Successful adaptation does not just mean developing the resilience of our assets through the delivery of adaptation action on the ground. As Case Study 1 shows, we have also worked hard to build adaptive capacity within our processes and procedures.

The Adaptation Reporting Power

3.18 We have been a willing and active participant in the development of the adaptation reporting power, sharing our experiences in understanding the implications of climate change for our business. We are pleased to submit this report on our approach to adaptation and believe that it will demonstrate that we have taken the implications of climate change seriously. We have created a governance structure to manage the implications and embed the need for adaptation throughout our decision-making processes.

3.19 This report will explain how we:

- have developed our thinking on climate change over time
- have evaluated the risks pre and post UKCP09
- have developed an internal structure to build adaptive capacity
- are now delivering adaptation actions
- will continue to monitor, review and report on these actions in the future.

3.20 As many of our strategic publications already incorporate climate change adaptation we will not reproduce them in this report. Where adaptation issues under discussion are included in them we will signpost the full document, for example our WRMP and FBP for 2010 - 2015.

3.21 Similarly, we do not see the role of this report as a new business plan process. We have not included detailed options or Cost Benefit Analysis (CBA) for any actions that we have identified. These have either been included within our current business plan, or will be included in the next appropriate one, as and when any investigations are complete and an investment proposal is being made.

3.22 We believe that the purpose of this report is to demonstrate how we are taking the implications of climate change into account in all of our business as usual processes. It will show that we have the governance and mechanisms in place allowing us to use the best available science to evaluate the risks and that we are prepared to include sustainable adaptation solutions in our business plans. We set out this aspiration when we published our SDS in 2007 and we believe that this report will demonstrate our commitment to creating a business that will be robustly adapted to the challenges of climate change.

3.23 It is our strongly held belief that we cannot successfully adapt in isolation. In evolving our approach to adaptation we have recognised that, at a business level, we need the commitment and support of our investors, customers, suppliers and regulators. We hope that the submission of our report, alongside those of the other reporting bodies, can aid in the development of a comprehensive National Risk Assessment and a coordinated approach to delivering an adapted UK.

Case Study 1

BS 25999

After the 2007 summer flooding the Pitt Review recommended that essential service providers should be resilient to a consistent standard. British Standard (BS) 25999 for Business Continuity Management was set as the minimum. This covers an organisation's business continuity needs and provides an external basis for assessment against them including operational, customer, legal, regulatory or any other requirements.

We already had externally assessed quality management systems in place with robust emergency / event responses, including defined continuity arrangements for our critical water and wastewater operational activities. However as these did not meet all of the BS 25999 requirements and included some additional resilience needs, such as security, senior management agreed to integrate these requirements with an existing system.

In August 2008 our current external assessment / certification body 'Lloyds Register of Quality Assurance' (LRQA) completed a system gap analysis which identified common management system elements, BS 25999 specific requirements and our additional needs. These were used to create a Business Resilience Management System based on our existing Water Services intranet-based quality system. This incorporated all facets of business resilience, whilst still fulfilling requirements for compliance, external assessment and certification to BS 25999.

Bringing together and formalising existing activities for business improvement as well as attaining BS 25999 gave additional benefits including consistency within our resilience management arrangements and with industry best practice. It also contributed to our SDS priority of increasing the resilience of our critical water and wastewater services.

Following technical review by LRQA certification to BS 25999-2:2007 was confirmed and the certificate was presented to our Managing Director on 16 March 2010. We were the first UK water company to achieve external certification for these requirements.

4 Evolution of climate change thinking in Anglian Water

Key messages

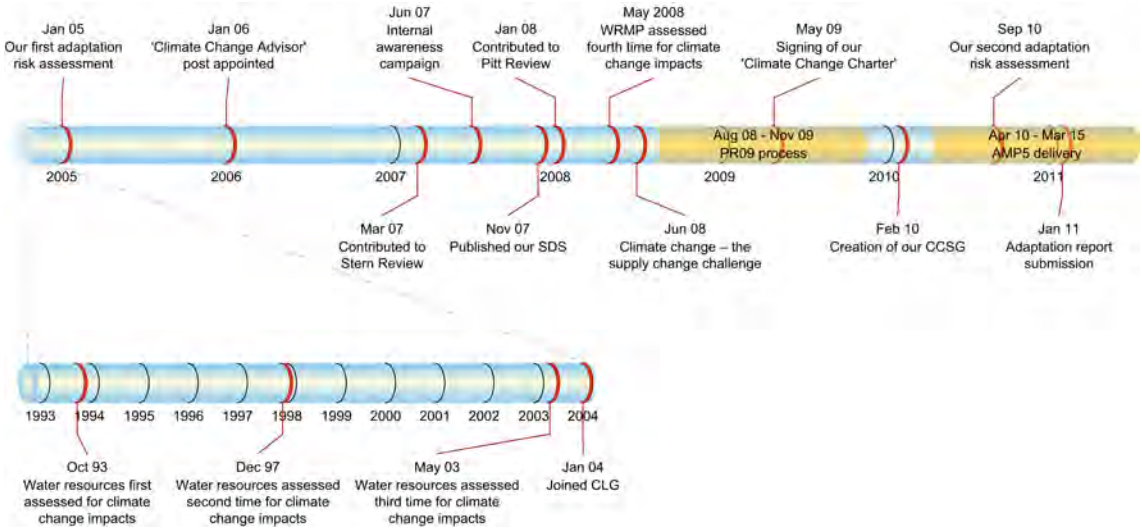
1. Our understanding of the implications of climate change began nearly two decades ago with its consideration in the assessment of our water resources in 1993.
2. In the last five years we have thoroughly considered climate change implications for our business; creating a new team, dedicated steering groups, risk assessments and developing commitments.
3. We are heavily engaged in the debate at a local, regional and national level with key bodies helping us take a step-change in our approach to climate change.
4. Using this information we have sought advice from our expert opinion panels, receiving insight into customer and stakeholder priorities on adaptation priorities.

Understanding adaptation

4.1 Initially our focus on climate change was on the implications for water resources. Climate change projections are used in the development of our WRMP and have been since 1993. Energy use and efficiency has also been a major focus for our business for more than 10 years. This has evolved into a three strand approach to carbon management: energy-efficiency, renewable generation and the reduction of embodied carbon in the creation of new assets.

4.2 In 2005, prompted by a challenge from our then CEO, we examined the climate change projections and their implications for the rest of our business more thoroughly. This highlighted how we need to adapt to ensure a successful business in a future with a changing climate. Figure 4.1 'Our climate change adaptation action' picks out some of the more important milestones along this journey.

Figure 4.1 Our climate change adaptation action



4.3 In July 2005 the Regulation Department made an initial assessment, to understand the potential future climate that our region would be subject to. Whilst this was being completed, it became obvious that a cultural shift in how we considered climate change was essential.

4.4 In September 2005 an initial report was put before the Management Board with two key recommendations. The first was that the portfolio for climate change should be held at Board level by the Director of Regulation. The second was that the recruitment of a new climate change post should be approved. As a result the Climate Change and Environmental Performance Team was developed, and in 2006 we appointed our first climate change advisor.

4.5 From the outset, our approach was that climate change had the ability to impact on every part of our business. This meant that although our response would be coordinated and monitored centrally, the whole business had a part to play, just as they did in reducing our greenhouse gas emissions. Adaptation to climate change became part of the reporting governance of our Corporate Responsibility Committee with individuals throughout the company, who were potentially responsible for delivering elements of adaptation, being brought together to feed into the assessment process.

4.6 Raising awareness of the implications of climate change with our employees was considered a priority, so an internet site was created and a company wide series of awareness sessions were undertaken. These were based around the film 'An Inconvenient Truth'. Specific sessions were also run for our senior staff, 'key communicators', the Human Resources team and the Management Board.

4.7 In 2007 our SDS publicly stated that climate change was now one of the key challenges that we faced in planning for the next 25 years. This would also be a focus for the next five year business plan 2010 - 2015.

4.8 In 2008 the importance of adaptation was included as part of an energy and climate change conference that we organised to engage with our supply chain. At this event we encouraged our suppliers to develop a baseline of their carbon footprint and to investigate how they needed to adapt their business to climate change. This event was followed up with one to one sessions with a number of key suppliers.

4.9 By 2009 we had developed a climate change charter, which was signed in the presence of the Secretary of State for the Environment, Food and Rural Affairs. We then reviewed the governance of climate change within the business and a new reporting structure was created including the CCSG, chaired by the Director of Regulation, reporting to the Management Board. This group brought the two strands of mitigation and adaptation together at a strategic level.

4.10 In 2010 we accepted Ofwat's FD for AMP5 and defined our approach to efficiently and effectively deliver the investment allowed for 2010 - 2015. Part of this new strategy included a set of business-wide objectives with climate change at their core, such as *"the effective management of the impacts of growth and climate change on our region"*.

Engaging in the climate change debate

4.11 In developing our internal adaptive capacity we recognised at an early stage that adapting to climate change could not be achieved in isolation, particularly for a regulated business. In order for us to successfully build adaptation into our decision making processes it was important to develop a network of external organisations who could provide advice and support.

At the international level

4.12 One of the key influences that led to a step-change in our approach to climate change was our involvement in the Prince of Wales Corporate Leaders Group (CLG). We were founder members of the group when it was established in 2004. Working alongside 20 leading companies across the UK drove us to establish a greater understanding of the role we had to play in adapting our business to the challenges of climate change and to become a champion for adaptation.

4.13 We were a founder signatory of the CLG's 2007 Bali Communiqué, which attracted the support of businesses worldwide. In 2008, we were a founder signatory of the Poznan Communiqué which builds on the Bali Communiqué, and urges world leaders to step up their diplomatic efforts on the issue of climate change. In 2009 and 2010 we again signed the communiqués associated with Copenhagen and Cancun, respectively, urging for action on carbon reduction and delivering adaptation.

4.14 We also take an active role, through Water UK, in the discussions at a European level as part of EUREAU. We chair the EUREAU Climate Change Task Force which brings together all parties involved in the European water sector and has been active in raising the importance of adaptation in continuing to deliver successful water and wastewater services across Europe. We are also the EUREAU representatives on both the European Union (EU) Adaptation Steering Group and the EU Common Implementation Strategy Group for Climate Change and Water.

At the national level

4.15 Until relatively recently, adaptation understandably remained in the shadow of the enormous challenge of reducing greenhouse gas emissions. However we recognised at an early stage that climate change was a significant risk to the future success of our business and our region. We were keen to engage in the debate at the national level and share our understanding of the challenges.

4.16 In order to do this we made a conscious decision to engage pro-actively and have contributed to consultations and enquiries, including the:

- UK National Adaptation Policy Framework
- Stern Review
- Pitt Review
- Climate Change Bill
- Royal Commission for Environmental Pollution consultation on adaptation
- Environmental Audit Committee enquiry on adaptation.

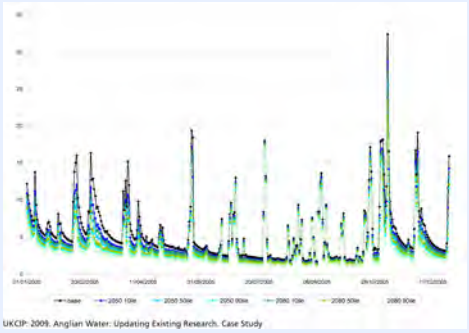
Case Study 2

UKCP09 launch 'web site case study'

As we had worked with UKCIP on trials of the UKCP09 data, we were invited to submit a web-based case study to accompany the official launch. We provided a study detailing a derived method which used the data to assess climate change impacts on reservoir yields: a worked example for our Grafham Water reservoir was included.

The method simulates river flows and reservoir yields using climate change scenarios and the Stanford Watershed (SW) (rainfall-runoff) and OSAY (yield calculator) models. Precipitation and temperature data plotted on a cumulative distribution function were obtained from the UKCIP User Interface and used to calculate monthly change factors for combinations of temperature and precipitation probabilities. These were then applied to a baseline time series to derive the following datasets required to model the reservoir yield:

Figure 4.2 Simulated river flows at Offord, 2005 series

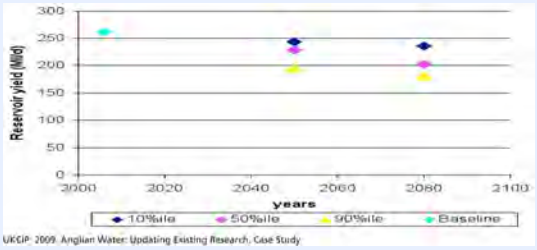


- daily rainfall series at a sub-catchment level and for the reservoir
- weekly evapotranspiration for the relevant Meteorological Office Rainfall and Evapotranspiration Calculation System squares.

Rainfall and evapotranspiration daily time series were also obtained from the weather generator for comparison with the sampled data.

The SW rainfall-runoff model simulates river flow using daily rainfall and evapotranspiration and the OSAY model then calculates the reservoir yield from the SW model river flows. Examples of the simulated river flow output and reservoir yields for a range of rainfall and temperature probabilities are shown in Figure 4.2 'Simulated river flows at Offord, 2005 series' and Figure 4.3 'Calculated reservoir yield' respectively. These outputs were generated using the UKCP09 dummy data.

Figure 4.3 Calculated reservoir yield



It is intended that the methodology detailed will be used to evaluate climate change impacts on proposed water resources schemes and the robustness of our water resources system and supply / demand balance.

4.17 As a water company we do not face the challenges of understanding these new risks in isolation. Water UK represents all UK water and wastewater service suppliers at national level. It provides a positive framework for the water industry to engage with government, regulators, stakeholder organisations and the public.

4.18 Through Water UK our industry has developed a climate change network which places a high priority on building adaptive capacity. UK Water Industry Research (UKWIR) provides a framework for the procurement of a common research programme for UK water operators on 'one voice' issues including adapting to climate change. This programme has included projects on water resources, adaptation risk assessment and examining the effects of climate change on water and wastewater infrastructure.

4.19 The ability to draw on the expertise of UKCIP to develop and validate our approach to understanding and managing adaptation has been invaluable. From the early stages we have made use of the tools provided by UKCIP but more importantly we have been able to create and maintain a two-way dialogue with them as our understanding has developed. Over the past five years UKCIP has provided valuable input at senior level discussions, at workshops to explore the implications of the scenarios on different business areas and most recently in the development of our first quantitative climate change risk tool using UKCP09.

4.20 We saw the creation of the new UKCP09 tools as one of the most important developments and were keen to offer our support in their development. This culminated in our Water Resources Management Team working on a case study using dummy data for the launch of the UKCP09 data and website (see Case Study 2). Due to the delayed release of the UKCP09 data, our current WRMP was generated using the UKCIP02 data and it is not due for full review until 2015. Preparing this report however was an opportunity to use the UKCP09 data outside of the standard regulatory programme in line with our culture of continual review.

At the regional level

4.21 Understanding the framework at the national and international level is important but it is at a regional level where the majority of the action will need to be taken. In our journey to build our adaptive capacity, we have had to consider how our adaptation requirements link with those of other organisations, to deliver adaptation action in the region.

4.22 Through 'The Working Together Initiative' we have been working closely with the EA to improve the strategic understanding and communication between our two organisations. A key workstream has focused on climate change and our organisations have continued to exchange relevant information. The EA provided us with flood data and models to inform our risk assessment of fluvial and coastal flooding for use in PR09. Correspondingly, we have been able to provide data on our asset location and function so that it can be included in their review of Shoreline Management Plans.

4.23 We have actively contributed to the work of the East of England Climate Change Partnership (now Climate East). This is managed and supported by the East of England Development Agency (EEDA), GO-East, EA, Improvement East and the East of England Local Government Association. We have contributed to the development of regional reports and led seminars on the implications of climate change and importance of water for the region. We have also contributed to a number of local authority adaptation plans (Norfolk, Peterborough and Bedford) and we chair the Multi-agency Critical Infrastructure & Essential Services Group in Lincolnshire (see Case Study 3).

Case Study 3

Lincolnshire: mapping of critical assets

We chair Lincolnshire's 'Multi-agency Critical Infrastructure & Essential Services Group'. During 2010, this group was asked to hold a series of workshops looking at four issues relating to critical infrastructure along Lincolnshire's coastal strip:

- identifying assets
- assessing their ability to continue to provide services during a flood
- highlighting interdependencies between asset owners
- service restoration time frames.

The workshops were attended by local representatives and asset owners including CE-Electric, British Telecom and the local Internal Drainage Boards. They were an opportunity to review and update a geographical information system for Lincolnshire, which already contains sites including telephone exchanges, electricity sub stations, water and wastewater assets and vulnerable community assets such as blue light services and schools. Key locations were highlighted where the impact of community flooding would be significantly worsened by infrastructure failure. Information from the workshops will feed into Lincolnshire's Multi-Agency Flood Plan.

> *"The workshop sessions have been an excellent way of gaining greater knowledge of infrastructure assets in Lincolnshire's coastal region, and the implications of a flooding event on the communities they serve. Local knowledge proved invaluable in providing the right kind of detail for the plan. Members of central emergency planning teams are less able to highlight particular local issues than the manager looking after assets in that area."*
>
> Lincolnshire's Multi-agency Critical Infrastructure & Essential Services Group

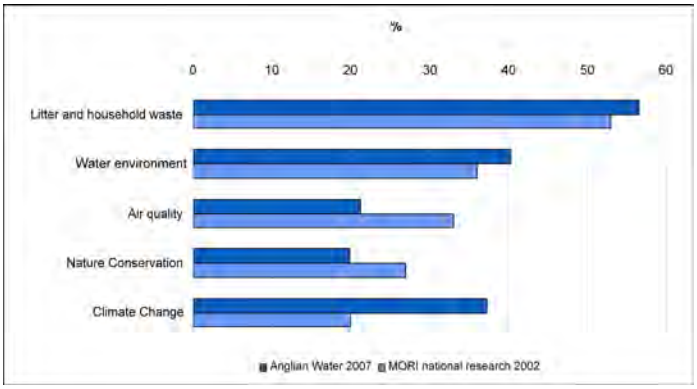
The workshops will continue until the the vulnerability of critical infrastructure to flooding has been assessed for the whole county. The information will feed into the Multi-Agency Flood Plan, and will be reviewed as part of the Lincolnshire Local Resilience Forum's document control process.

4.24 With a more operational focus it has been important for us to be properly embedded into the Local Resilience Forums (LRF) created as a requirement of the Civil Contingencies Act 2004. These are formed by emergency responders and specific supporting agencies designated as 'Category 1 and 2 Responders' under the Act. These are based on police force boundaries and act as the principal mechanism for multi-agency cooperation in fulfilment of the responders' duties under the Act. LRF assess risks to the communities they serve and develop plans to address these risks. They already plan for severe weather but climate change projections indicate that in the future LRF may need to consider how the long term changes in climate will affect their capacity to respond. It is important that climate change should not only be addressed as a risk in its own right but rather that the potential effects of climate change are taken into account when assessing other risks.

Using this engagement to deliver action

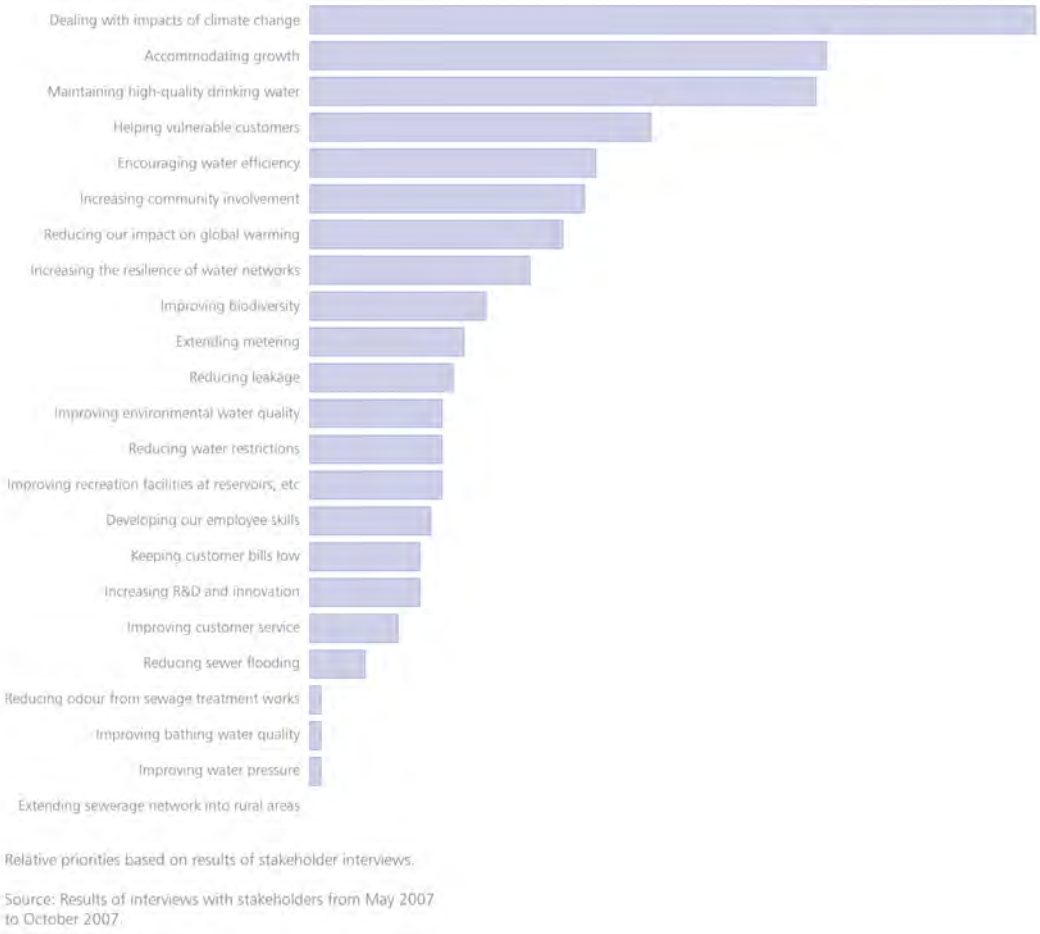
4.25 In 2007 we carried out a customer survey to gauge their attitude towards environmental issues. For comparison purposes it asked the same questions as a national survey from 2002. This showed a major increase in the priority given to climate change (see Figure 4.4 'Customer priority survey 2007').

Figure 4.4 Customer priority survey 2007



4.26 This was backed up in 2007 by our stakeholder engagement work which clearly ranked 'dealing with impacts of climate change' as the top issue. This was published in our SDS and can be seen in Figure 4.5 'Stakeholder priority survey'.

Figure 4.5 Stakeholder priority survey



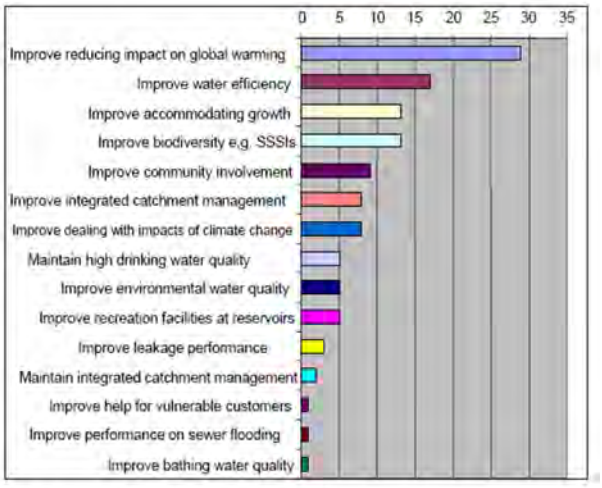
4.27 Building on this we established five independently chaired Regional Expert Opinion Panels at the outset of the PR09 process. These consisted of around 60 individuals, representing customers, consumer and citizen groups, business, local and regional government bodies, non governmental organisations, development authorities, academia and special interest groups.

4.28 These advisory panels were set up to comment on our activities and proposed programmes of work. They offered guidance for our future performance in relation to residential customer services, business interests, the environment, patterns of future growth in water and wastewater service requirements (in the context of the possible impacts of climate change) and finally Hartlepool Water dealing with all of these matters but at a specific regional level.

4.29 These groups have provided valuable feedback by:

- allowing more in-depth consideration of issues and priorities than is possible in a survey
- discussing issues that are important in service provision but which are not usually visible to customers directly, for example planning for growth
- giving an independent and considered view.

Figure 4.6 Environment Expert Opinion Panel priority results



Source: Environment Expert Opinion Panel Report 2008

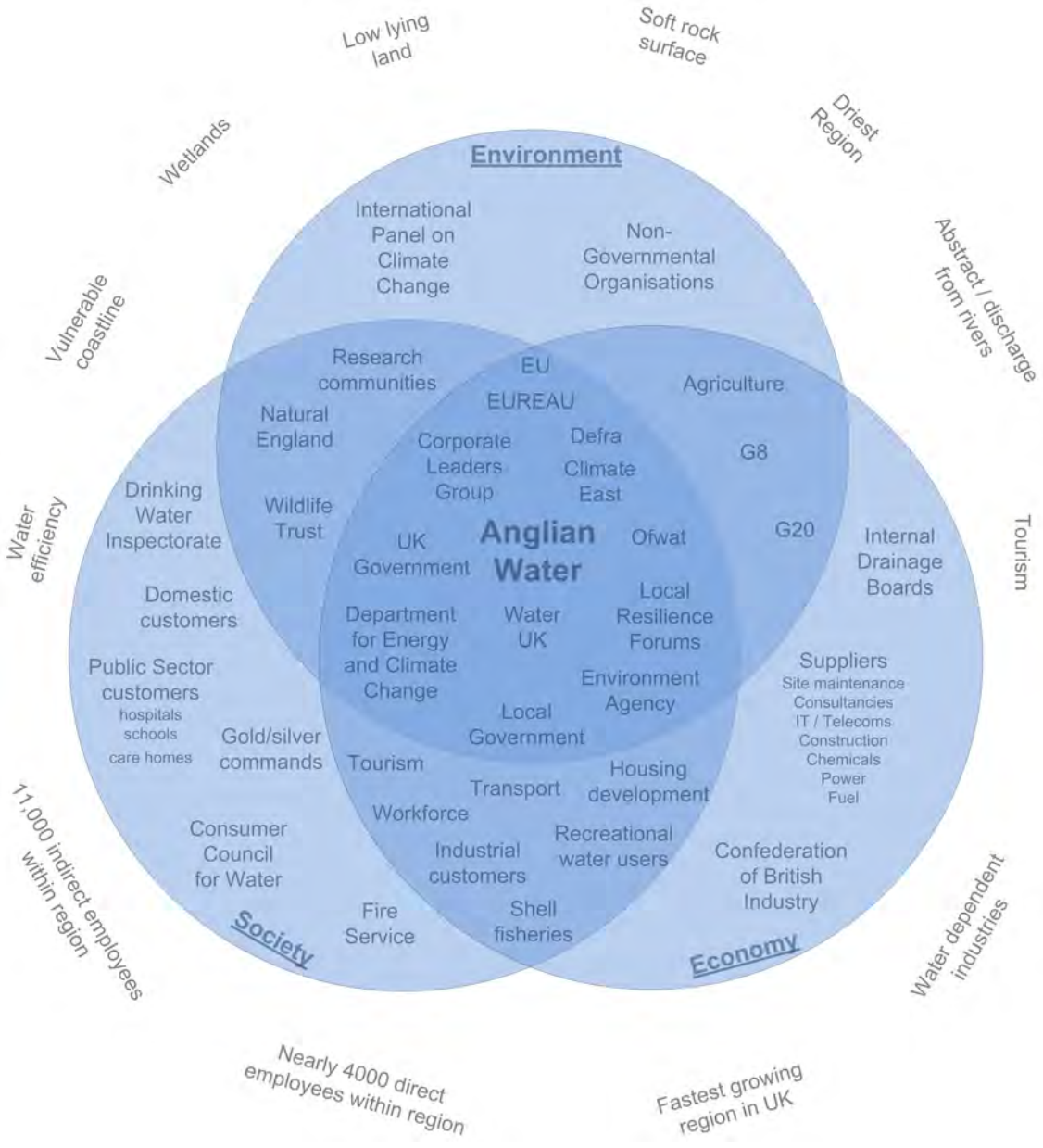
4.30 Their discussions reinforced our focus on climate change as a key priority. The Environment Expert Opinion Panel gave particular support in its recommendation report provided to us in advance of our Draft Business Plan (DBP) for AMP5. It showed that this panel's top priorities included living with global warming and climate change, see Figure 4.6 'Environment Expert Opinion Panel priority results' and the quote below.

> *"We accept the compelling scientific evidence that the climate of the Region is changing as a result of increased 'greenhouse gases' through human activity. There will be an increasing risk of more frequent extreme weather events. The company needs to invest in technologies, which will adapt to the new and expected climates as part of its day to day service. In overall terms we agree that there will be major stresses and demands on water resources and a consequent degradation of the environment, if these pressures are not dealt with sustainably."*
>
> Environment Expert Opinion Panel DBP Report on Key Priorities.

4.31 This level of engagement enabled us to create a business plan submission for 2010 - 2015 that was supported by a wide range of regional and national stakeholders. The plan includes investment to build our adaptive capacity and to deliver the first elements of direct and indirect adaptation actions on the ground.

4.32 Sustainable adaptation needs to balance the requirements of the economy, the environment and society in order to be successfully implemented. Figure 4.7 'Our place in the adaptation web' shows our place within the web of interactions, between us and our stakeholders, necessary to achieve this.

Figure 4.7 Our place in the adaptation web



5 Managing our risk - a historical perspective

Key messages

1. A company climate change risk assessment was completed using the UKCIP02 projections. This identified that our key climate change risks are increased flooding of assets, coastal erosion and changes in water resources availability.
2. An internal communications campaign was launched to raise awareness of these issues as a first step in building adaptive capacity.
3. Our SDS and business strategies incorporated the key findings of this risk assessment.
4. Projects and research were carried out to assess the impact of key risks and generate business cases for our PR09 FBP.
5. Ofwat's FD did not support investment for a number of the adaptation actions in our FBP.

Using UKCIP02 to understand our risk

5.1 Our original risk assessment in 2005 used the UKCIP02 projections in a qualitative manner. This looked at the headline changes that were projected for the East of England and examined the potential impacts on the main operational areas of the business. The interpretation drew on technical experts from across the business and from a working group that had been established to agree the outputs and priorities for action.

5.2 This process resulted in a matrix showing the climate change parameters and the potential impacts for each of the areas of our business. This matrix was reviewed when the post of Climate Change Advisor was appointed in 2006 and a variant of the matrix was included in our SDS. Table 5.1 'Our original risk assessment results'shows a summary of the original findings with the addition of a qualitative risk score.

Table 5.1 Our original risk assessment results

	Potential climate change	Potential impact	Risk score(1)
Water resources	Temperature rise	Increase in demand for water in summer Increased evapotranspiration	4 x 3 = 12 (medium)
	Winter rainfall increase	Increased diffuse pollution	3 x 3 = 9 (medium)
		Opportunity for more winter storage	opportunity
	Summer rainfall decrease	More frequent low river flows Increased competition for water degraded wetlands	4 x 3 = 12 (medium)
	Sea level rise	Saline intrusion	1 x 1 = 1 (none)
	Increase in weather extremes (heat waves, intense rainfall, storms)	Increased run-off reduces recharge of aquifers Reduced river water quality	3 x 2 = 6 (low)

	Potential climate change	Potential impact	Risk score[1]
Water supply and customer service	Temperature rise	Increased peak demand Changes in process efficiency	3 x 2 = 6 (low)
		New pests and diseases	2 x 2 = 4 (low)
		Faster asset deterioration	2 x 2 = 4 (low)
	Winter rainfall increase	Inadequate pump capacity for raw water	2 x 3 = 6 (medium)
	Summer rainfall decrease	Increased peak demand Changing customer expectations	3 x 2 = 6 (low)
	Sea level rise	Asset loss	2 x 4 = 8 (high)
	Increase in weather extremes (heat waves, intense rainfall, storms)	Increased flooding and risk of service loss	2 x 4 = 8 (medium)
		Increased subsidence – pipe failure	2 x 3 = 6 (medium)
		Decrease in raw water quality – increased treatment cost Security of power Peak demand delivery during heat waves	2 x 2 = 4 (low)
Wastewater collection and treatment	Temperature rise	Faster asset deterioration	2 x 2 = 4 (low)
		Improved wastewater compliance	opportunity
		Changes in process efficiency Increase in odour	2 x 2 = 4 (low)
	Winter rainfall increase	Insufficient infrastructure capacity	4 x 2 = 8 (medium)
	Summer rainfall decrease	Tightening of discharge consent Reduced flexibility – effluent required to maintain river flows	4 x 2 = 8 (medium)
	Sea level rise	Asset loss	2 x 4 = 8 (high)
	Increase in weather extremes (heat waves, intense rainfall, storms)	Increased flooding and risk of service loss	2 x 4 = 8 (medium)
		Increased subsidence – pipe failure	2 x 3 = 6 (medium)
		Inability of infrastructure to cope	4 x 2 = 6 (medium)
Asset creation / construction programme	Temperature rise	Impact on construction processes Site staff exposure to ultra violet (UV)	2 x 1 = 2 (none)
	Winter rainfall increase	Narrower construction window	2 x 1 = 2 (none)
	Summer rainfall decrease	N/A	N/A
	Sea level rise	Fewer suitable site locations	3 x 1 = 3 (none)

	Potential climate change	Potential impact	Risk score[1]
	Increase in weather extremes (heat waves, intense rainfall, storms)	Change to design standards	3 x 2 = 6 (low)
Social implications	Temperature rise	Political pressure for prioritising essential water use – schools / hospitals	1 x 3 = 3 (medium)
		Economic pressure from increased tourism	4 x 2 = 8 (medium)
		Greater use of air conditioning, leading to increased energy use / emissions	3 x 1 = 3 (none)
		New pests and diseases	2 x 2 = 4 (none)
	Winter rainfall increase	Increased flooding of properties	3 x 3 = 9 (medium)
		Land required for new water storage	3 x 2 = 6 (low)
	Summer rainfall decrease	Exacerbating problems created through housing growth	N/A
		Reduced risk to bathing waters from combined sewer outflows	opportunity
	Sea level rise	Relocation of coastal populations	2 x 4 = 8 (high)
	Increase in weather extremes (heat waves, intense rainfall, storms)	Health and safety of staff	3 x 1 = 3 (none)
		Failure of bathing waters	3 x 2 = 6 (low)
		Increased insurance claims	4 x 2 = 8 (medium)

1. Calculated as likelihood multiplied by severity on a 5 by 5 matrix.

Rolling out the assessment and building adaptive capacity

5.3 In response to the outcomes of this assessment a number of projects to build our adaptive capacity were initiated. The understanding of the implications of climate change on water resources was already established and incorporated into the process for developing the WRMP. The implication of sea level rise was not so well understood and so an exercise to map the impact of a 0.4m sea level rise on our coastal assets was undertaken. Figure 5.1 'Our assets vulnerable to 0.4m sea level rise' shows the extent of this impact on our major coastal assets.

5.4 The outcomes of this project and work to assess the implications of shoreline management in our region were used as part of the awareness raising campaign that was undertaken in the company during 2007. This campaign, involving interactive sessions, workshops and web based information, was used to ensure that climate change was seen by all our decision makers as a matter for immediate consideration.

Figure 5.1 Our assets vulnerable to 0.4m sea level rise

Adaptation and business planning, the AMP5 link

5.5 Having established the need to deal with climate change as a key strategic priority for our business, our next step was to examine how we could integrate adaptation actions for our key climate change challenges into AMP5, 2010 - 2015. To ensure that we continue to provide our customers with our current high levels of service our SDS contained a number of strategic priorities for the next 25 years, these are illustrated in Figure 5.2 'SDS strategic priorities'[(1)]. A number of these refer to climate change explicitly or have aspects of climate change inherent within them, for example resilience.

1 Note. The page numbers within Figure 5.2 refer to pages in our SDS and not this report.

Figure 5.2 SDS strategic priorities

5.6 These priorities were used to shape our five-year business plan and in preparing for PR09 these priorities were combined with the key risks identified by our original risk assessment. They were used to inform and develop the series of detailed risk assessments and costing projects which produced the climate-related elements in the FBP submission. A selection of the major project outcomes is included in Table 5.2 'Our AMP5 priorities' to illustrate our proposed climate change actions and what was approved in Ofwat's FD.

Table 5.2 Our AMP5 priorities

Stated priority	Adaptation action included in our AMP5 FBP	Actions included in the FD
Secure the supply of reliable and resilient water and wastewater services	• four water resilience schemes to provide alternative supplies to major population centres in case of catastrophic outages • protect 27 water assets from fluvial and coastal flooding • protect 127 wastewater assets from fluvial and coastal flooding • alleviate flooding to 153 high risk internal, 25 low risk internal and 68 external areas • mitigate flooding impacts to 210 internal and 100 external problems	• three water resilience schemes to provide alternative supplies to major population centres • fluvial and coastal flood protection for 20 water assets • no schemes to protect wastewater assets from fluvial and coastal flooding • alleviate flooding to 102 high risk internal, 24 low risk internal and 68 external areas • mitigate flooding impacts to 210 internal and 100 external problems
Offer an innovative and affordable pricing structure.	All investments subject to CBA incorporating climate change	N/A
Ensure we meet our goal of limiting average bill increases to an average of less than 1% p.a. above inflation for the AMP5 period	All investments subject to CBA incorporating climate change	N/A
Build additional capacity in our networks to meet the needs of housing growth over the next five to ten years	Impacts of growth and climate change factored into the actions in this table and other relevant parts of our FBP such as the WRMP	Yes - however, our proposal to uplift our design standards for sewers (a 20% uplift in line with Defra advice) was not approved
Reduce even further the risk of customers being without water because of flooding, drought or exceptional events	• protect 27 water assets from fluvial and coastal flooding • four water resilience schemes to provide alternative supplies to major population centres in case of catastrophic outages	• fluvial and coastal flood protection for 20 water assets • three water resilience schemes to provide alternative supplies to major population centres
Actively encourage water efficiency, in particular by increasing the number of customers on meters	• enhanced metering for 183,320 properties in water-stressed areas, total metering submission • submission for Sustainable Economic Level of Water Efficiency (SELWE) activity, including research	• enhanced metering for 183,320 properties • full programme to deliver water efficiency but no investment for further research

Stated priority	Adaptation action included in our AMP5 FBP	Actions included in the FD
Safeguard the precious environment in which we operate	• all of the above actions • modelling and stakeholder engagement for 54 catchment schemes around nine WTW	• all 54 schemes, but only 75% of the proposed investment was approved
Allow us to further develop our business in a sustainable way for the benefit of all our customers	All of the above and additional actions	N/A

Assessing the cost of climate change for our FBP

5.7 We appraised the majority of our investment programme using CBA in two ways:

- to evaluate potential options for investments or levels of service and to assist in choosing the optimal solution
- to express the costs and benefits of an investment that had already been selected for inclusion in the programme as they were required by legislation.

5.8 The underpinning principle of CBA is to compare the benefits of an investment (both private and societal) with the costs (both private and societal) of such an investment. The key challenge for CBA is to derive monetary values for items with no readily marketable value. Climate change was not treated as a separate input into the analysis: it was seen as integral to the whole process.

5.9 We conducted a number of stated preference surveys to derive customers' willingness to pay for changes in service levels. These were used in conjunction with our internal Business Impact Matrices (BIM) and historic literature. All of the values and methods used were subject to extensive peer review and consumer engagement through regulatory meetings and regional expert opinion panels.

5.10 We use CBA routinely as an integral part of our business planning process and we see it as a 'design support' tool in our investment decision process (see Case Study 4). We will continue to make sophisticated use of CBA as part of our Asset+ investment optimisation process to assess the costs and benefits of our investment options.

5.11 This work was done in consultation with a variety of stakeholders, most notably our Expert Opinion Panels. Although they were very supportive of our work, its approach and the conclusions, they were concerned that Ofwat's FD would not fully reflect customers' preferences. Their conclusions on this matter can be seen in the following extract.

"The Panels understand that the guidance given for the preparation of the Final Business Plan did not allow for significant provision for climate change adaptation. This is reflected in the lack of any substantial provision for adaptation in the Draft Determination. We are concerned about this and urge that every effort is made to rectify this in the Final Determination. We recognise Ofwat's commitment to consider investment supported by new UKCP09 evidence as a notified item, but we are dismayed that this investment will only apply to water resources and not wastewater services. The Company is seen as an exemplar on climate change and the Panels do not want its progressive work to be held back in order to meet short term financial issues of recession.

We encourage Ofwat to promote a more sustainable approach by supporting sound investment proposals that address both adaptation and mitigation."

Response to the Ofwat Draft Determination of Price Limits for Anglian Water 2010-15, Independent Panels Advising the Company

Case Study 4

The benefits of fluvial and coastal flood alleviation measures

For our FBP we assessed the benefits of flood alleviation on our sites in terms of the avoided service impacts by investment in appropriate mitigation. These are summarised in Table 5.3 'Benefits of flood mitigation measures'.

Table 5.3 Benefits of flood mitigation measures

Asset type	Benefits - service impact avoided
Water assets	• interruption to supply • boil notices • health and safety hazards • loss of asset value.
WwTW	• loss of asset value • time of recovery • impact on the river ecosystem • impact on water supplies • transport of effluent and sludge.
Sewage Pumping Stations (SPS)	• loss of asset value • impact on the river ecosystem • impact on water supplies • transport of effluent.

The valuations of these impacts were derived using our valuation surveys outlined above. We then conducted CBA to inform our optimal investment programme to protect our assets from the risk of flooding.

Our AMP5 fluvial and coastal flooding proposal

5.12 Fluvial and coastal flood risk is likely to increase with climate change, having severe implications for society, the economy and the environment and causing interruption or contamination of water resources. As a response to this threat we need to plan for higher levels of risk by taking a fresh look at the vulnerability of infrastructure and enhancing our flood resilience. In our FBP we sought investment for fluvial and coastal flooding schemes, to protect our most vulnerable water and wastewater sites. Case Study 5 explains this partial success in securing investment for some of our most important water assets.

Case Study 5

AMP5 fluvial and coastal flooding

Ensuring that our water and wastewater services and assets are resilient to extreme weather events, particularly increasing flood risk, is a major adaptation challenge for us. This could lead to a rise in supply interruptions, a deterioration of raw water sources or contamination of supplies. It is driven by a combination of factors including increased winter rainfall, sea level rise, agricultural runoff and one million new homes planned for our region in the next 25 years.

To understand the exposure of our assets to these risks we overlaid our abstraction sites, WTW, WwTW and SPS on the EA Flood Zone 2 and 3 maps. Flood depths were then inferred from Digital Terrain Models and, where available, the more accurate Light Detection and Ranging data. For water supply sites EA flood maps and hydraulic models were used, in line with Defra guidance, to obtain flood extents for a range of return periods. Local knowledge and buffer zones were applied to account for uncertainties around the flood extents and the asset locations and sizes.

Asset flooding vulnerability was assessed by combining the above data with the results of site visits to determine the site-specific risks. Site information included flooding sources and pathways, location / height of sensitive equipment, existing and planned site defences and national flood defences. Prioritisation of sites identified as at risk was carried out by assessing the resilience of the water supply network and the impact of asset failure on water supply. This explored the location and population affected by outages under current and planned future system resilience using the MISER supply network model.

The preferred solution for improving asset resilience was the construction of embankments, with others including building walls, flood-proofing buildings and improving site drainage. Flexibility was incorporated by exploring options that could be delivered incrementally at minimal cost. In addition it was found that water supply network interconnectivity provided additional resilience resulting in a reduction in the scale of any solutions needed.

Confirmation of the reductions in population at risk was carried out with MISER to simulate service delivery before and after the implementation of the mitigation options. The assessment showed that the proposed mitigation options reduced the population at risk to below the level set by the Security and Environmental Measures Direction so confirming their suitability.

WwTW and SPS are difficult to protect in the same way as water sites. The policy was to flood-proof buildings containing vulnerable equipment, such as control panels, and to allow non-critical areas to flood.

As a result we proposed AMP5 adaptation investment at 27 water and 127 wastewater sites in our FBP. Future work will need to address the challenges of exploring other scenarios and probabilities, reducing and quantifying uncertainties, extending model coverage, simulating major flood types and estimating joint flood probabilities.

Resilience schemes

5.13 As part of our AMP5 submission, our water supply activities were scrutinised to assess what impact climate change may have in relation to supply failure. Where significant issues were encountered solutions were investigated and included in our FBP. An example of this is a WTW serving 829,000 customers in our Ruthamford Water Resource Zone (WRZ).

5.14 Our resilience investigation estimated that approximately 614,000 of the customers served would be affected by a major outage. The resilience solution proposed involved improving the connectivity in the system by installing a 106Ml/d gravity main connecting the WTW and a Treated Water Reservoir served by another WTW in the same WRZ.

5.15 In the event of a prolonged period of water scarcity this solution will enable us to use the resources of Rutland Water and our AMP4 Wing WTW extension to support demand in the vulnerable areas. It will also support the northern portion of the Three Valleys Water company supply system area. Since the transfer will rely on resources from Rutland Water, we will also be able to use storage in the reservoir to mitigate climate change effects.

Climate Change and the WRMP

5.16 In 2003 an UKWIR report ('Effect of Climate Change on River Flow and Groundwater Recharge – UKCIP02 Scenarios') indicated that there was a significant potential impact on river flows and groundwater recharge when using the UKCIP02 scenarios. However an independent peer review of the report recommended the need for a more substantial piece of work to underpin the methodology and address some of its perceived shortcomings, namely:

- users need a method for generating data from the regional averaging of the rainfall and population equivalent scenarios at improved resolution
- approach to uncertainty not rigorous enough
- method for regionalisation of catchment flow factors too coarse - should be developed based on catchment characteristics
- inadequate consideration of future natural variability and scenarios of climate change to develop a probabilistic interpretation of likely changes in river flows and recharge
- not demonstrated whether or not climate change had already had an impact on UK gauged river flows over the period 1970 - 2002. This means if trends cannot be detected in the measured flow data, the validity of the 2020 scenarios for predicting hydrological change should be questioned.

5.17 This made it clear that a new detailed methodology would be necessary to gain the appropriate understanding of climate change impacts for the development of the WRMP10. To do this a second project, UKWIR06, was commissioned and it was this that our Water Resources team used to generate our WRMP10. The use of this methodology is explained further in Case Study 6.

Case Study 6

The WRMP

Climate change in our region will probably lead to more winter rain, less summer rain, seasonal shifts, increased evapotranspiration and higher temperatures. These will reduce summer river flows, groundwater recharge, groundwater levels, water quality in rivers and reservoirs and cause changes in customer water usage. This is likely to increase the risk to water supply as resources are affected by reductions in yields and deployable outputs and increased average and peak demands.

The EA Water Resources Planning Guidelines are the framework for developing our 25 year WRMP, including how we will maintain the balance between water supply and demand. The guidelines drive adaptation by requiring us to consider the impacts of climate change and the options for maintaining the supply / demand balance.

A 2007 assessment of climate change on supply used methods developed in the UKWIR CL04 surface and groundwater reports. The assessment used the six UKWIR06 scenarios and the UKWIR 'Integrated_Spreadsheet_v3.0'.

Surface water yields were calculated for a baseline and the UKWIR06 scenarios with the median (defining the effect of climate change), maximum and minimum (defining the uncertainty boundaries) values being chosen. These were converted to Deployable Outputs (DO), constrained by WTW and abstraction licence capacities.

For groundwater the changes in levels were calculated for the six scenarios at the 25 sources considered most vulnerable to drought. This was done using a spreadsheet based, lumped, catchment-wide method called GR2. The UKWIR summary diagrams for each source and changes in level were used to assess the potential yields under each scenario. These were then converted to DO in the same way as above.

The impact on supplies was calculated as a loss of 29.3Ml/d in average daily DO.

The 2009 climate change and Demand for Water project medium-high 'Provincial Enterprise' and 'World Market' scenarios were used to estimate the impacts on demand. For Anglian Region WRZs in the mid 2020s these gave household and non-household demand uplifts of 1.8% and 2.6% respectively. Climate change impacts pre and post 2025 were calculated by scaling.

The additional combined impact of supply loss and demand increase on the supply-demand balance in 2036-37 would be 49.6 Ml/d concentrated in four of the 11 WRZ. In the near-term it is proposed that the supply demand investigations and four resilience schemes in our AMP5 FBP will deal with this. Longer term a new winter storage reservoir in South Lincolnshire is proposed to support the regional supply / demand balance.

5.18 Although this was carried out, we excluded any climate change contribution to water supply / demand in our FBP on the advice of Ofwat:

> *"Our current analysis, fulfilling requirements from the EA and supporting the Water Resources Management Plan, indicates that climate change impacts are very marginal in AMP5 and do not drive the need for significant investment within our region. We will review our climate change analysis after publication of the UKCP09 report".*
>
> 2009 FBP, Sections B5.2.1 - B5.2.2.18

5.19 In response to this we have started to review our WRMP (see Case Study 8). However it is acknowledged that further work will need to be done to continue to re-evaluate our conclusions based on the release of UKCP09.

Preparing to deliver adaptation actions

5.20 Since 2005 we have been working to build our understanding of the implications of climate change and to improve the adaptive capacity of our business. We have done this with technical knowledge from within our business, but have also engaged with experts within our region and beyond. This encouraged us to invest in a number of actions to increase the resilience of our water supply immediately and enabled us to develop a FBP that included important adaptation investments. Although the FD did not support investment in all of these areas, most notably in fluvial and coastal flood protection for our wastewater assets, we have a significant programme of adaptation investment to deliver in AMP5.

6 Delivering adaptation

Key messages

1. We are now delivering AMP5 adaptation actions on the ground.
2. We have identified key knowledge and adaptation capacity building actions, which we need to undertake to inform future delivery.
3. We have a programme of measures in place for delivery of current and future adaptation work.
4. Adaptation is being delivered as either specific capital funded site-based solutions or through operational expenditure on adaptation capacity building throughout the business.
5. Although we may wish to deliver adaptation actions, our regulatory determination can be a barrier when investment is not approved.

Adaptation in action

6.1 We have acknowledged climate change as a strategic risk to our business. Even if emissions are curbed in the near future, past emissions have locked in inevitable climate change over the next few decades and we must adapt in order to keep delivering our vital service. Our risk assessments have identified the priorities for adaptation investment and these were included in our AMP5 FBP.

Delivering adaptation through AMP5

6.2 The investment priorities to be delivered in 2010 - 2015 as approved in the FD are:

- alleviating fluvial and coastal flooding at 20 water sites
- reducing or mitigating sewer flooding for 504 properties
- increasing water supply resilience - three schemes
- demand management including enhanced metering for 183,320 properties and water efficiency
- the catchment management programme.

Alleviating fluvial and coastal flooding

6.3 We operate more than 6,900 water and wastewater assets, a number of which are vulnerable to the effects of fluvial and coastal flooding. To ensure that we can deliver our high quality continuous water and wastewater services to our customers we assessed the likelihood of fluvial and coastal flooding at these sites for our PR09 submission. Details of our assessment, selection and prioritisation of the schemes can be seen in Case Study 5.

6.4 Ofwat's FD allows investment to improve the level of fluvial and coastal flooding protection at 20 water sites, which includes benefits to 1,023,615 consumers from an increase in the security of their water supply by increasing protection to floods of <1 in 100 year return period. During the AMP5 period site evaluation and specific designs will be developed so that construction will be complete by 2015. Solutions will range from full site protection

through to the protection of specific assets on site. These may include the use of impermeable barriers such as reinforced concrete walls or earth bunds, specialist renders and coatings to waterproof buildings and raising items of equipment above projected flood levels.

6.5 For PR14 we anticipate using a similar benefit valuation process to that used for the PR09 submission (see Case Study 5). The individual benefit values will however be updated, to reflect current figures and the outputs of a current EA project on costing the environmental benefits of flood protection for WwTW. The 1 in 1,000 year return period storm represents an extreme event. More analysis for failure likelihood at different frequencies, such as 1 in 200 years or 1 in 500 years, will be undertaken to develop a revised risk position if the flood height data is available. This may give different costs for flood protection.

6.6 The protection of assets from fluvial and coastal flooding will form part of our risk based investment planning process. The optimal plan is balanced against the level of proposed investment across all drivers and the impact on customer bills.

Reducing sewer flooding

6.7 The provision of an effective drainage network to remove waste water and storm water from properties is essential in a modern society. To serve our 2.5 million domestic and commercial properties, we rely on more than 44,000 kilometres of sewers and rising mains, more than 1,100 WwTW and more than 4,500 SPS. As part of improving our services to customers we are seeking to alleviate sewer flooding to high risk properties during the next 10 years.

6.8 Much of the combined and surface water sewer networks have been assessed against a storm return period of 1 in 30 years at a particular rainfall intensity and have proven to perform satisfactorily against this standard. As the influence of climate change on rainfall intensity for the 1 in 30 year standard increases, the performance of those areas of the network which are currently satisfactory may deteriorate. The monitoring of sewer performance is, and will continue to be, a key area for us and any change in performance will promote investment at the appropriate time.

6.9 In order to reduce the number of properties at risk of being flooded (either internally or externally) owing to the inadequate capacity of the existing sewerage system we proposed an improvement programme in our AMP5 FBP. At the end of March 2010 the number of properties on our high risk (1 in 10 years and 2 in 10 years) internal 'DG5 risk register' was 302 with approximately 311 on the internal 1 in 20 year register and 1,440 external areas on the register. In our FBP we proposed to reduce the high risk internal flooding by 153 properties by the end of March 2015 with additional improvements in the 1 in 20 and external registers. However the FD did not fully support the extent of the sewer flooding programme, although the principle of designing for a future climate change scenario was accepted.

6.10 Our proposed investment programme was optimised using CBA techniques which, for the benefit evaluation stage, used both the company private costs (internal costs) and the societal values for alleviating properties being flooded with sewage.

6.11 In developing the cost element of the CBA, a number of potential sewer network improvement options are often considered. Our normal sewer design standard is to provide systems capable of accepting flows from a 1 in 30 year return period storm for internal flooding and a 1 in 20 year return period for external flooding. The design of the future sewerage system must accommodate changes in rainfall intensity due to the impacts of climate change. To provide an improved understanding of these changes we commissioned

the Meteorological Office to undertake a brief review of current research and provide an assessment of the potential changes in rainfall intensity. Their report concluded that by 2080 we should design for a 20% increase, with winter extreme events being at twice the current frequency.

6.12 In developing conceptual designs for sewerage improvements to alleviate sewer flooding we utilised computer models of the sewerage system with rainfall events taken from the Flood Studies Report (FSR) hyetographs. A number of these designs were re-modelled with the revised assumptions on rainfall intensity to reflect the 2080 position. This re-modelling indicated that, to maintain the 1 in 30 year design standard, increased attenuation storage, a larger pipe size or more probably a combination of the two options would be required. The most effective solution for a particular location would depend on site-specific details such as topography and land availability. The increase in the overall programme estimated costs to meet this revised design standard is 35% although individual project solutions will vary from this.

6.13 In assessing the most appropriate solution we will take account of whether modular solutions are available to accommodate any uncertainties in design standard. For instance if a particular solution required 1,000m^3 of attenuation storage we would consider whether installing 500m^3 would provide sufficient protection in the shorter term, for example to 2050. If at 2050 some of the uncertainty around future rainfall intensity had been resolved we would plan to construct the remaining storage in accordance with those improved assessments. The decisions on the most effective solution at any particular point on the scheme time-line will primarily be taken on 'whole life cost' grounds but will also take into account a number of factors such as land use or availability patterns.

6.14 Table 6.1 'Change in design solutions for current assessment against the FSR recommendations' provides some examples of the change in design solutions explored for the current FSR recommendation assessment and the revised design assumptions for 2080.

Table 6.1 Change in design solutions for current assessment against the FSR recommendations

Location	FSR solution	FSR cost £k	Revised solution(1)	Revised cost £k
1	75m^3 offline storage	501	135m^3 offline storage	653
2	200m^3 online storage, 260m sewer 525mm diameter	840	365m^3 online storage, 260m sewer 525mm diameter	1,200
3	61m^3 offline storage	444	150m^3 offline storage	666

1. Flood Estimation Handbook (FEH) plus climate change

Increasing water supply resilience

6.15 The challenges we face as a company are detailed in our SDS. In particular the following factors were identified, which all had a strong bearing on both our WRMP and FBP:

- **Housing growth:** Our region is one of the fastest growing in the UK and contains several areas identified by Government for the development of sustainable communities

- **Population growth:** From the Office of National Statistics data, we are forecasting average population growth in our region of 0.8% p.a.; equivalent to an additional 220,000 people by the end of AMP5
- **Climate change:** As the driest region in the UK we are vulnerable to climate change effects that may include hotter, drier summers. Based on UKCIP02 scenarios we forecast that climate change will reduce our WTW DO by approximately 29 Ml/d by 2025. Some of these reductions will occur in areas of limited supply where the impact is significant. In these and other parts, increased demand during increasingly frequent periods of hot, dry weather will also challenge our ability to maintain levels of service
- **Environmental pressures:** Our region contains a large number of ecologically important habitats of national/international importance. Future sustainability reductions in water abstraction determined by the EA could be substantial
- **Deteriorating water quality:** Intensification of agriculture, poor management practice and accidents have resulted in various chemicals being released into our raw water supplies. Although we treat the water supply to remove harmful chemicals, we remain vulnerable to the threat of diffuse and point source pollution.

6.16 Our SDS states that climate change is the biggest single risk facing us over the next 25 years. Our assumptions on climate change are guided by the advice of UKCIP and take account of the EA and Ofwat's reporting guidelines. The changes most significant for managing water resources would be a reduction in summer rainfall, with an associated increase in temperature. In combination, these may reduce the length of the winter recharge season and increase the demand for water. At this time the impacts of climate change on deployable outputs, forecast demands and headroom have not been included in our WRMP or FBP, as directed by regulators, but may be included in future plans.

6.17 In the long term, the challenges we face will be met by developing a fully integrated water resources and water supply system which is resilient and provides our customers with a safe and reliable supply of water.

Table 6.2 Our resilience projects

Description	Activity output	Service standard output	Completion date
Humberside resilience	Network reinforcement	47,841 properties (62,281 consumers) benefit from reduction in risk of supply loss from 1:1000 to 0	2012-13
Ruthamford resilience	Improved connectivity	280,016 properties (613,592 consumers) benefit from a reduction in the risk of supply loss from 1:1000 to 0	2016-17
Lincolnshire resilience	Extension of supply / demand scheme	65,902 properties (100,713 consumers) benefit from a reduction in the risk of supply loss from 1:1000 to 0	2014-15

6.18 In our FBP we proposed the delivery of four resilience schemes, for dependant populations of 50,000 or more, in South Humberside, Ruthamford and Lincolnshire. These investments support our overall strategic aim and take account of climate change effects. The FD approved investment for three schemes, but one of our proposed schemes for Lincolnshire was not approved. Details of the AMP5 schemes are shown in Table 6.2 'Our resilience projects'.

6.19 To increase resilience in areas vulnerable to long-term supply interruption we have developed a phased approach, starting with our most vulnerable customers. Our AMP5 investments tackle potentially exposed populations greater than 50,000. In AMP6 we will focus on populations between 30,000 and 50,000.

Demand management

6.20 In our SDS we lay out our long-term supply / demand strategy including our plans to promote water efficiency as a key element. The paragraphs below detail how we will achieve this through the delivery of our following priorities in the AMP5 period:

- 126,000 optant and selective metering installations for customers who request to switch to measured supply or unmeasured customers who we chose to switch owing to their high rates of discretionary use
- 183,320 enhanced (accelerated) metering installations for Planning Zones (PZ) where there is significant supply / demand deficit
- water efficiency measures including 87,500 audits with free installation of water efficiency measures
- maintaining the Sustainable Economic Level of Leakage (SELL) through additional leakage control such as pressure reduction and leak detection and repair.

6.21 Our current meter penetration is more than 60% of our customers and twice the national average. In AMP5, we will continue to promote household metering. We believe that this is a fair way to charge customers and that the water-related savings will help us meet the twin challenges of climate change and growth. Our overall target is for 80% of customers to use meters by 2014-15 and for full meter penetration by 2035.

6.22 Proposals for compulsory metering are targeted to areas where there are significant supply / demand deficits in the short to medium-term. Given the challenges of future climate change scenarios this enables us to mitigate the risk of future restrictions on use and the environmental consequences of additional abstraction on the same basis as our efficiency programme.

6.23 In June 2008 we agreed, with Ofwat, a Base Service Water Efficiency target of 1.9Ml/d. This will be achieved by providing water saving devices, advice and information to both household and non-household customers including schools. For AMP5 we have secured investment for a programme of 87,500 household water audits and retrofits in areas that have been designated as water stressed. Completion of this programme will achieve the Sustainable Economic Level of Water Efficiency as agreed with Ofwat.

6.24 With leakage equivalent to half the industry average of $10m^3$/ kilometre of main per day, our leakage performance is amongst the best in the industry. In combination with metering and water efficiency measures this has allowed us to restrict the growth in demand. In AMP5 we will maintain our leakage target based on maintaining the two elements of SELL: short run (our baseline activity) and long run (additional activity for zones in deficit).

The catchment management programme, capturing serendipitous adaptation benefits

6.25 There has been a regulatory shift of expectation on water companies from 'traditional' end of pipe solutions, to catchment management, which is expected to extend to AMP6 and beyond. In AMP5 we are undertaking catchment management in response to a number of drivers including:

- the Drinking Water Inspectorate's (DWI) requirements under the Drinking Water Safety Planning process
- Defra's Water Strategy (2008) encouraging water companies to work with farmers to tackle pollution at source
- our commitment in the SDS to a sustainable approach to management of drinking water quality
- Water Framework Directive (WFD) Article 7.

6.26 Catchment management is an AMP5 quality enhancement programme of work addressing deteriorating raw water quality. It is required for regulatory compliance and is supported by the DWI and EA in our PR09 FBP and investment was approved by Ofwat. The programme supports a multi-agency approach to promoting, implementing and assessing the impact of catchment management measures intended to improve raw water quality at source. Catchments have been targeted where WTW show a currently high or rising trend in contaminants such as pesticides and nitrates. Under the DWI schemes, 13 surface water and seven groundwater WTW have been identified for catchment management to address nitrate or pesticide non-compliance. The EA Water Quality National Environment Programme prioritises 34 groundwater WTWs, principally to address nitrate problems.

6.27 The catchment management strategy involves a number of different work areas. These include stakeholder liaison, monitoring, data acquisition and analysis, investigations and surveys, scenario modelling and support for third-party catchment initiatives.

6.28 Stakeholder liaison will be undertaken to gain understanding of stakeholders' roles, working relationships, influences and interests. It will also aim to raise awareness of pollution-induced drinking water quality compliance issues, build up knowledge of catchments feeding our sources, review the effectiveness of voluntary measures and stewardship incentives and help to identify priorities and influence third-party work.

6.29 Scenario modelling, monitoring, data acquisition and associated investigations and surveys will aim to gain a better understanding of catchments and how the various processes operating within those catchments influence raw water quality interaction. The key aspects of catchment hydrology and hydrogeology together with current and historic land-use and pesticide / nitrate application data will be analysed and modelled with a view to assessing the likely success of potential risk mitigation and water quality remediation measures.

6.30 The case for catchment management and climate change mitigation is more obvious as a successful programme would lead to benefits including less treatment and reduced energy demand. Although the catchment management programme has not been developed to specifically respond to climate change there will be serendipitous adaptation benefits.

6.31 Through the catchment management programme, it will be possible to track changes to the characteristics of the catchments from which we obtain our water resources. Climate change could lead to changes to irrigation water availability, crop yields, growing seasons, new varieties of crops and livestock, increased sediment run off, soil erosion, increased water pollution and increased flooding frequencies. All these factors have the potential to

impact on the quality of raw water abstracted at our sources, and the corresponding change in risk to water quality would be monitored and assessed within the catchment management programme.

6.32 Through engagement with the third parties identified as influencing water quality in the catchments of interest we will work in partnership to engage stakeholders and ensure they are well informed. We will work to understand risks and thresholds, including associated uncertainties. By its nature, work in catchments to improve water quality will be long-term and a phased approach will be necessary to cope with uncertainty. Wherever possible, catchment management measures will be aimed at delivering cost-effective solutions and multiple benefits. The continued effectiveness of any adaptation decisions within the catchment management programme will be assessed by adopting a continuous improvement approach that also includes monitoring and re-evaluation of risks.

Additional adaptation actions

6.33 Whilst AMP5 will deliver significant portions of our climate change work it is not the sole source of action in this area. Within AMP4 (2005 - 2010) we undertook a number of activities to better understand and adapt to a number of our more significant climate change adaptation risks.

Figure 6.1 Rutland lagoons

Resilience schemes

6.34 During 2005 - 2010, we saw the delivery of two significant water resilience schemes. One was an AMP4 funded scheme in our Ruthamford supply zone involving the construction of a new WTW at Morcott, 41 kilometre of distribution pipelines and habitat enhancements at Rutland Water. Whilst the driver for this scheme was regional population growth it will also make the supply more resilient to the pressures of climate change.

Figure 6.2 Morcott WTW construction

6.35 The second scheme entailed the construction of an alternative source of supply and associated transfer pipework for our Heigham WTW. This was funded as a direct reinvestment from our profits (see Case Study 7).

Case Study 7

Norwich resilience scheme

During AMP3 / AMP4 the risks associated with medium to long-term outage at sourceworks were managed by constructing high specification plants with significant standby capacity. Such works were termed 'robust'. However, while 'robust' works mitigate risk associated with process failure, they provided little protection against the effects of a catastrophic event such as flooding, fire, earthquake, large scale or sudden pollution and climate change.

In 2005 a lack of resilience was identified as a major issue for 18 PZ in our region. This was based on a vulnerability assessment which categorised 'dependant populations' as those greater than 50,000 who receive more than 70% of their supplies from a single treatment works.

With the recognition that some of our larger communities were facing unacceptable risks of extended loss of supply, improving the resilience of our network became a strategic aim. We determined that urgent action was necessary to improve resilience of the water supply systems serving the cities Norwich and Peterborough and the surrounding areas, each with a population of more than 250,000. In 2006 we committed to investing £40 million of investors' funds to reduce the risk of the extended loss of water supply to customers in these cities.

To increase the supply resilience for Norwich we investigated the possibility of using the nitrate blending chalk boreholes at Costessey Pits as an emergency supply in the event of a catastrophic loss of the Heigham WTW output. These now provide standby capacity for 70% of the average daily demand served by Heigham WTW. The remaining standby capacity has been provided by upgrades to the demand control on a number of other WTW thereby providing a total resilience of 110% of average daily flow.

In 2006 we also addressed the progressive deterioration of raw water supplies to Norwich and the dependency on the direct river intake on the River Wensum through the Yare Valley Security and Emergencies Measures Direction scheme and also advanced the Caistor nitrate reduction scheme. To complete each of these projects we identified the importance of securing and developing separate sources of supply that would provide extra capacity to the supply system and increase our flexibility to respond to possible future climate change impacts.

Shoreline Management Plans

6.36 The region which we serve has a long and generally low-lying soft-rock coastline with many significant estuaries, embayments and a large coastal plain. Lincolnshire, for example has approximately one third of its land at or below sea level. Our coast is also experiencing habitat loss in front of the sea defences and high levels of development in the fastest growing region of the UK. The UKCP09 projections for the high emissions scenario suggest that climate change will result in a sea level rise of 22 to 82cm as well as more frequent and severe storms and a greater height and intensity of storm surges. This will lead to higher coastal erosion and an increased risk of coastal flooding due to overtopping.

6.37 The management of coastal erosion and flood defence in the UK is via a series of SMP. Each of these covers an area of 'linked' coastal processes and brings together all of the stakeholders to deliver a defence strategy which balances the environmental, social and economic needs of the area covered by the plan.

6.38 All six SMP in our region have recently undergone review and we fed into their policy development at a regional level. We also provided local input in the form of Geographical Information System data of our assets to ensure that all relevant data was taken into account when formulating the new plans. The outputs from the SMP will be analysed by our Asset Planning teams in order to understand if any investment proposals will need to be included in the PR14 process.

The role of innovation in delivery

6.39 We are currently involved in a number of climate change related research projects including two engineering doctorates sponsored by the Engineering and Physical Sciences Research Council in collaboration with us and Yorkshire Water. These are:

- Climate Change Impacts on Above Ground Water Infrastructure
- Climate Change Impacts on Buried Water Infrastructure.

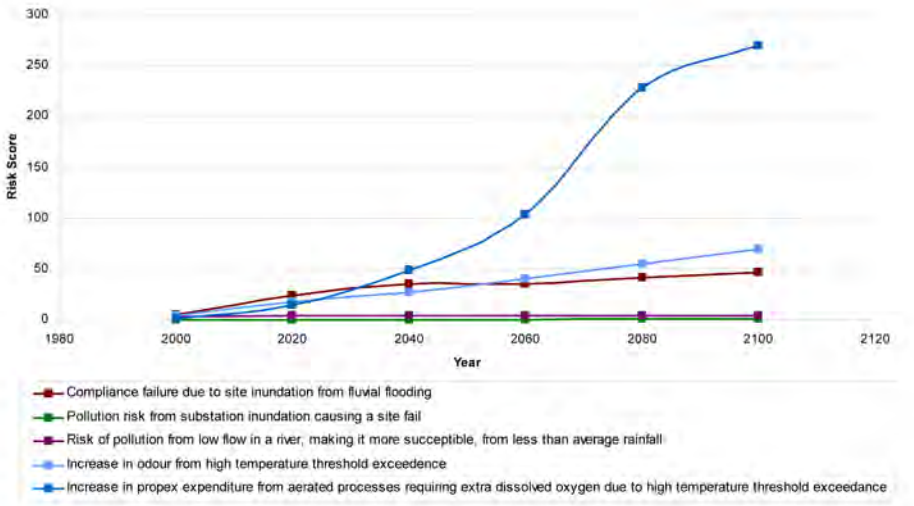
6.40 During AMP5 we will establish a strategic climate change network with the Grantham Institute at Imperial College, the initial aims of which will be:

- identifying research needs of the water industry to build capacity to address the impact of climate change
- developing collaborative research proposals focused on climate change adaptation and mitigation
- assisting in the development of adaptation strategies to cope with the uncertainties inherent in climate change
- influencing key stakeholders and identifying other research partners.

6.41 The completion of this report has identified areas requiring further or new research and it is intended that these will be incorporated into the Innovation programme of work through the newly established climate change workstream.

6.42 An example of a potential innovation project is illustrated below in Figure 6.3 'Risk scores for each consequence affecting individual WwTW', which shows a depiction of the consequences to WwTW from our new risk assessment. Although it identifies site inundation as the biggest threat to our business currently, it also indicates that from 2040 this risk will be overtaken by temperature effects on aeration. The inclusion of this within our programme of measures and the potential for adoption into the Innovation workstream demonstrates our continuous review cycle.

Figure 6.3 Risk scores for each consequence affecting individual WwTW



Our programme of measures

6.43 We have been working to understand the impacts of climate change on our whole business since 2005. This has included projects to build our adaptive capacity and, as we have outlined in this section, how we intend to deliver adaptation actions on the ground. Table 6.3 'Programme of measures key actions' summarises some of the key actions that we:

- have already completed
- will be delivering in this AMP period
- will be investigating for future AMP periods.

6.44 The full programme of measures is overseen by the CCSG and they are responsible to the Management Board for reviewing it on a regular basis and ensuring that projects are prioritised appropriately and delivered on time.

Table 6.3 Programme of measures key actions

Action	Climate change impact	Project details	Target date	Status	Further work
Fluvial and coastal flood risk assessment for FBP	Increased risk and severity of fluvial and coastal flooding	Flood mitigation options to tackle flood risk have been suggested and put in the context of existing resilience in our system. The options and CBA for 154 sites were included in the PR09 FBP. The FD gave support for 20 critical water assets but did not support the wastewater assets	31 March 2008	Complete	Delivery
AMP5 FBP resilience submission	Growth, summer demand, peak demand, water resources availability	Included four resilience schemes in FBP, Ofwat's FD approved three. These are now moving into the AMP5 delivery phase	2010	Complete	Delivery
Assess vulnerability of our assets to coastal erosion and flooding. Identify key assets under threat	Sea level rise, increase in storminess	List of assets predicted to be affected by coastal erosion and / or flooding generated in detail for sub-cell 3b of the Norfolk coastline. For the rest of our coast a 300m zone inland was used. The main conclusion was that climate change had a greater effect on the risk of flooding than on erosion	01 September 2008	Complete	SMP work has superseded the work outside sub-cell 3b. Sub cell 3b will give greater detail to SMP predictions
Meteorological Office rainfall extreme project	Pluvial flood risk	New standards developed and incorporated into sewer design for specific projects in PR09. Not supported in FD	31 March 2008	Complete	Identified as a barrier. Review work in view of UKCP09 and re-assess how to take forward with Ofwat
Review of WRMP	Precipitation change and temperature change	WRMP10 incorporating climate change projections signed off by Defra and published	31 January 2010	Complete	5 year rolling review with annual reviews for EA. Review in light of UKCP09
UKCP09 review	Water resources availability	Understanding of changes due to UKCP09 and recommend further work. Results identified a non-significant impact on a sample of surface water sources	01 January 2010	Complete	Employ guidance from EA / UKWIR projects when available
Adaptation of water company drought plans	Water resources availability	Plan incorporates consideration of current climate change projections - review depending on EA requirements	July 2008	Complete	3 year rolling review (2011)
Evaluate potential impact of sea level rise on water resources	Sea level rise, saline intrusion	Mott MacDonald report. Desktop study for groundwater and surface water sources using UKCIP02 high emission scenarios for 2050 and 2080	01 January 2009	Complete	Reassess for PR14
Reevaluation of our climate change risk assessment, to become quantitative	Temperature increase, flood, extreme rain	Using our established R and V processes to develop a robust quantitative risk assessment of the impacts of climate change on our asset base	30 September 2010	Complete	Validate the tool then review climate change adaptation strategy and actions
Growth and water cycle studies	Growth, summer demand, peak demand, water resources availability, wastewater treatment	Water cycle study consultants guide has been produced. There 46 studies of which 42 are in progress. Of those in progress 11 are in early stages, 14 are at the outline stage and 17 are at the full strategy stage.	From 2009 onwards	Ongoing	Implement actions
AMP4 Wing resilience scheme delivery	Growth, summer demand, peak demand, water resources availability	Increased resilience of water resource position with mitigated environmental impact	2010	Complete	Habitat areas being completed and monitored

Action	Climate change impact	Project details	Target date	Status	Further work
AMP4 Norwich resilience scheme delivery	Growth, summer demand, peak demand, water resources availability	Increased resilience of water supply in the event of catastrophic loss of Heigham WTW. 110% resilience	2010	Complete	
Opportunities for water resource sharing	Water resources availability	Undertake a project with other water companies in the region to explore if sharing or trading water resources will lead to customer or environmental benefits	2010	Complete	
Synergies in adaptation with Natural England (NE)	All	Work with NE to explore the common issues of adaptation within the region	2010	Complete	
Analyse validity of climate change projections and operational thresholds, within new risk tool	Temperature increase, flood, extreme rain	Improvement of risk tool and validation for all our assets	2011	Ongoing	Review tool conclusions and outputs
Review Asset Management procedures to incorporate climate change into asset design	Temperature increase, rainfall change	Climate change factors considered in all asset creation decision making processes and a Capital Delivery Process (CDP) that fully accounts for the impact of climate change	2012	To start	Review as appropriate
Biosolids review	Temperature changes, precipitation changes, land use changes, flooding	We will commission a review of our Biosolids activities to ensure climate change is fully incorporated into our planning	2012	Ongoing	
Climate change impacts on above ground water infrastructure	Higher Soil Moisture Deficit, faster asset deterioration, ground shrinkage	STREAM project to characterise the nature and extent of threats to buried assets from predicted climate change in the sponsors' operational areas. Develop a quantitative methodology for evaluating asset climate change vulnerability and defined adaptation interventions. Identify financial and service reliability costs of adaptation The methodology is to be fully compatible / integrated with our R and V process	31 November 2013	Ongoing	Explore links with UKWIR CL09 and CL10 projects. Compare with outputs of Yorkshire Water project
Investigate impacts of climate change on water demand	Summer demand, peak demand, water resources availability	A PhD to investigate the impacts of climate change on water demand to be undertaken with Loughborough University	2013	Ongoing	
'Whole system' analysis project on Adaptation and Resilience to Climate Change (ARCC)	Floods, droughts and heat waves	PhD student looking at a part of ARCC project to: ● Assess the risk of climate change impacts on water infrastructure systems and improve the performance of the water supply / demand system under future extreme events that will drive system failure (floods, droughts, heat waves) ● Design robust water-supply infrastructure systems at regional and local scales by identifying packages of measures that guarantee reliable water supplies at competitive costs, meet carbon commitments and are socially and environmentally acceptable	2014	Ongoing	Collaborate with other stakeholders in consortium project
Catchment management programme	Duration of summer and winter rainfall and periods of drought	Identify climate change benefits of catchment management such as less treatment, reduced energy demand, resilience of catchments and changes in catchments due to climate change	31 March 2015	Ongoing	Programme to be delivered in AMP5

Action	Climate change impact	Project details	Target date	Status	Further work
Fluvial and coastal flood risk assessment post PR09 and UKCP09	Increased risk and severity of fluvial and coastal flooding	Flood risk submission for AMP6. Develop business case with EA for environmental benefits of protecting priority wastewater assets	PR14	To start	PR14 preparation
Deliver AMP5 fluvial and coastal flooding schemes	Increased risk and severity of fluvial and coastal flooding	1,023,615 consumers benefit from an increase in the security of their water supply by increasing flood protection to <1:100 return period including the impacts of climate change	2014-15	Ongoing	Detailed design of flood protection at each site using more recent flood information and site survey
Deliver AMP 5 resilience schemes	Growth, summer demand, peak demand, water resources availability	Deliver the agreed resilience projects in Humberside, Ruthamford and Lincolnshire to secure supply.	31 March 2015	Ongoing	
Demand management - enhanced metering	Water resources availability, (peak) demand, summer demand, demand management	From the programme, we expect an average water demand reduction of 10% per property. Other outputs: ● installation of 183,320 meters by the end of AMP5 in the targeted areas, including 11,300 intelligent meters in Colchester ● The latter will give us a more efficient means of gathering meter readings and monitoring household flow data and provide the householder with a display unit situated inside their property	31 March 2015	Ongoing	Review for PR14
Reduce sewer flooding	Flood risk, extreme rainfall	In our FBP we proposed to alleviate flooding to 153 high risk internal, 25 low risk internal and 68 external areas and mitigate flooding impacts to 210 internal and 100 external problems by the end of March 2015. The FD allows us to alleviate flooding to 102 high risk internal, 24 low risk internal and 68 external areas and mitigate flooding impacts to 210 internal and 100 external problems	31 March 2015	Ongoing	Implement schemes
Embed adaptation in the PR14 submission	All	Ensure that all outputs from the programme of measures feed into the PR14 process and the generation of the submissions	2014	Ongoing	
Influence resilience of our Supply Chain Management (SCM)	All	Adaptation incorporated into SCM supplier selection process. Suppliers engaged on adaptation assessment and actions in their businesses		To start	
Study into increasing temperature effects on aeration processes at WwTW	Temperature increase	An understanding of the temperature impacts on differing aeration processes including thresholds, timescale and implications		To start	An adaptation plan
Continual review of inputs and outputs of quantitative climate change risk assessment	Temperature increase, flood, extreme rainfall	As new data emerges and data is validated the tool will be updated so that its outputs can be monitored and appropriate action taken	Rolling	Ongoing	Adaptation measures
Review our programme of measures	All	Ensure the appropriate level of adaptation within the business	Rolling	Ongoing	Additional actions

Enabling successful adaptation

6.45 We already have a significant amount of adaptation action underway but not all of the investment that we proposed in our FBP was approved. Investment for 20 water flood protection schemes was approved but no investment for wastewater sites.

6.46 This disparity appears to have arisen due to different views between Ofwat and ourselves regarding the calculation and interpretation of certain elements within CBA used as part of the investment process. If this situation continues it will represent a significant barrier to funding our successful adaptation and we will not be able to meet our obligations to our customers in the face of climate change. In order to address this we have entered into a dialogue with our regulators to better align our approaches to CBA.

6.47 An agreement on how adaptation requirements will be assessed in the next periodic review is a priority that we, the industry and Ofwat recognise. An early understanding on all sides of how adaptation can be delivered through the current regulatory framework is key to successfully delivering adaptation actions on the ground from 2015 onwards.

7 Reevaluating our risks in response to UKCP09

Key messages

1. We have developed our climate change risk assessment methodologies from qualitative to quantitative.
2. We have worked with UKCIP on our use of UKCP09 to reevaluate our climate change risks in line with our risk and value methodologies.
3. Our reevaluation has proved that the conclusions of our first risk assessment were correct, validating our AMP5 adaptation investments.
4. In addition, new trends and avenues for investigation have been identified, the results of which will inform future business plans.
5. The risk assessment tool and its conclusions are part of an iterative process which will be subject to review and improvement.
6. The information, tools and support from UKCIP is a vital combination of resources, without which we could not have completed this risk assessment.

UKCIP02 versus UKCP09

7.1 Our original climate change risk assessment, carried out in 2005, used a qualitative methodology (see Section 5) along with UKCIP02 data to identify the associated risks to our business. This used business expert opinions to assess the UKCIP02 projections and produced a risk table identifying:

- which areas of the business would be affected
- how they would be affected
- by what climatological effect
- the timescale during which the effect would be likely to occur

7.2 That table formed our original matrix of climate change implications and adaptation actions for which an overview can be seen in Table 5.1 'Our original risk assessment results'. A common theme in our approach to climate change is regular review and our risk assessment has been no exception.

7.3 As the UKCP09 projection release was delayed we were unable to complete a full review of our risk assessment in time for our PR09 submission. However we were able to use the UKCP09 user interface to generate climate change projections for a range of climate variables for the East of England and the East Midlands (see Table 7.1 'UKCIP projections for the Anglian region'). These were then used to reexamine our climate change risk assessment, at a high level. We concluded that the differences in the projection figures were not significant enough to immediately change our original risk assessment conclusions.

Table 7.1 UKCIP projections for the Anglian region

UKCIP02		UKCP09[1]				
			East of England		East Midlands	
Climate variable	**UK**	**Climate variable**	**Range**	**Central estimate**	**Range**	**Central estimate**
Increase in annual average temperature (ºC)	2 to 3.5	Mean winter temperature increase (ºC)	2.0 to 5.7	3.7	2.0 to 5.6	3.6
		Mean summer temperature increase (ºC)	2.4 to 7.5	4.5	2.3 to 7.3	4.4
		Mean summer daily maximum temperature increase (ºC)	2.8 to 10.6	6.2	2.7 to 10.3	6.0
		Mean summer daily minimum temperature increase (ºC)	2.6 to 8.4	5.0	2.5 to 8.2	4.9
Reduction in annual precipitation (%)	5 to 15	Annual mean precipitation change (%)	-6 to 8	1	-7 to 9	1
Increase in winter rainfall (%)	10 to 35	Winter mean precipitation change (%)	7 to 57	26	6 to 54	25
Reduction in summer rainfall (%)	35 to 50	Summer mean precipitation change (%)	-53 to 4	-27	-50 to 4	-25
	Eastern England		**Great Yarmouth**		**Grimsby**	
Sea level rise (cm)	22 to 82	Sea level rise (cm)	17.1 to 69.4	44.7	16.7 to 68.7	43.8

1. All figures are based on the high emissions scenario in the period 2070 - 2099 (centred on the 2080s). The probability range used is from 10% to 90% with the central estimate being 50%.

7.4 Ofwat recognised that the PR09 timescale did not align with the release of UKCP09, so they included a notified item in their FD. This would allow any changes to WRMP schemes to be considered for an Interim Determination of K (IDoK) during AMP5. In response to this we used UKCP09 projections to carry out a review of our surface water abstraction modelling using the UKWIR06 rapid review project tool 'Integrated_Spreadsheet_V3.0' (featured in Case Study 6).

7.5 This showed that the projected changes in precipitation and evaporation from UKCIP02 to UKCP09 would not have a significant effect. On this basis we agreed with the EA that we will not revise the WRMP until the WRMP14 review. Any changes to be made would be included in our next business plan submission and not as an IDoK for AMP5.

Our new risk assessment tool

7.6 The latest review of our risk assessment involved us taking the opportunity to reassess our methodology and develop a quantitative approach. This takes advantage of the step change in complexity and functionality of the climate change projection data from UKCIP02 to UKCP09. To ensure that this assessment was aligned with how risks are managed across the business, the project was undertaken with our R and V team.

7.7 The purpose of R and V is to support investment decision making and to ensure an understanding of ongoing business risk. The understanding of risk in economic terms is used to challenge investment needs throughout the asset creation process. This ensures an optimum balance between performance, risk and cost. The R and V challenge has been applied in our business since 2005.

7.8 The new climate change risk assessment tool builds on the existing qualitative method developed by Water UK with MWH. Doing this using the same economic risk evaluation methods as our R and V process means that the new tool is consistent with our other approaches to risk assessment.

7.9 As our water resources planning has incorporated climate change since 1993, it has not been necessary to include any climate change effects on water resources within the new tool (see Section 4).

How the risk assessment tool functions

7.10 The tool is being used to identify high-level trends in how asset types may react to climate change. Significant trends will trigger further, more detailed, studies. It has not been possible to assess all of the risks to our business with this new tool as it is asset focused. Those risks which do not relate directly to assets, for example those with more social or behavioural consequences, continue to be reviewed through our qualitative assessment.

7.11 The new methodology makes better use of the new UKCP09 data and UKCIP interface, allowing us to improve our evaluation of climate change impacts on our assets. Although the tool is an improvement on our previous risk analysis we recognise that there are a number of uncertainties and assumptions that needed to be made during its construction.

7.12 The tool is split into two parts, one for water assets and one for wastewater assets. Both parts of the tool however reference a common source for the assumptions and climatological data. Both the water and wastewater elements detail the key site types and

their characteristics which may define a given site, for example size or flood risk zone. Each site type and unique combination of characteristics is then evaluated against a range of different climate change driven failure modes or risks.

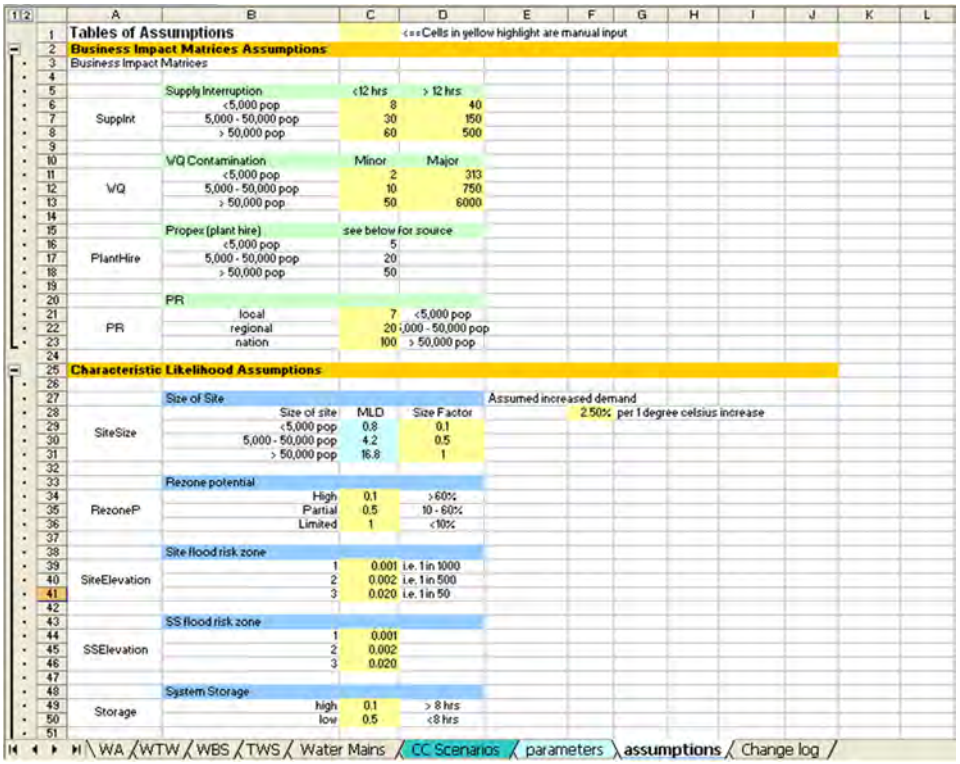
7.13 The evaluation of risk is in economic terms and is based on a combination of:

- an assessment of the risks to the asset and their likelihood (see Figure 7.1 'Some assumptions and likelihoods used')
- the impacts of these risks using data from our BIM
- climate change multipliers derived from the new UKCP09 data (see Table 7.2 'Climate change thresholds and their multipliers, from baseline to future').

7.14 Common to both parts of the tool is a table containing climatological data in the form of climate variable multipliers associated with a changing climate at 20 year intervals up to 2100. The baseline data for our tool is taken from the weather generator and is based on 1961-1990 for rainfall and 1961-1995 for all other variables. Due to the formulae used in the time slice calculation of the tool, the year 2000 is used to represent this baseline data. Although the UKCIP projection data only goes up to 2080, data for 2100 has been calculated based on the trend of the other four outputs. This is to accommodate the lifespan of some of our assets.

7.15 Business impacts are expressed in £'000s and are derived from the BIM that are used throughout our business for investment appraisal. Likelihood assumptions have been derived from current asset performance and / or business unit expert opinion (see Figure 7.1 'Some assumptions and likelihoods used'). They represent the likelihood of occurrence per year and, in conjunction with the BIM, enable the calculation of an annual economic risk.

Figure 7.1 Some assumptions and likelihoods used



1	Tables of Assumptions			<==Cells in yellow highlight are manual input	
2	**Business Impact Matrices Assumptions**				
3	Business Impact Matrices				
5		Supply Interruption	<12 hrs	> 12 hrs	
6		<5,000 pop	8	40	
7	SupplInt	5,000 - 50,000 pop	30	150	
8		> 50,000 pop	60	500	
10		WQ Contamination	Minor	Major	
11		<5,000 pop	2	313	
12	WQ	5,000 - 50,000 pop	10	750	
13		> 50,000 pop	50	6000	
15		Propex (plant hire)	see below for source		
16		<5,000 pop	5		
17	PlantHire	5,000 - 50,000 pop	20		
18		> 50,000 pop	50		
20		PR			
21		local	7	<5,000 pop	
22	PR	regional	20	,000 - 50,000 pop	
23		nation	100	> 50,000 pop	
25	**Characteristic Likelihood Assumptions**				
27		Size of Site		Assumed increased demand	
28		Size of site	MLD	Size Factor	2.50% per 1 degree celsius increase
29	SiteSize	<5,000 pop	0.8	0.1	
30		5,000 - 50,000 pop	4.2	0.5	
31		> 50,000 pop	16.8	1	
33		Rezone potential			
34		High	0.1	>60%	
35	RezoneP	Partial	0.5	10 - 60%	
36		Limited	1	<10%	
38		Site flood risk zone			
39		1	0.001	i.e. 1 in 1000	
40	SiteElevation	2	0.002	i.e. 1 in 500	
41		3	0.020	i.e. 1 in 50	
43		SS flood risk zone			
44		1	0.001		
45	SSElevation	2	0.002		
46		3	0.020		
48		System Storage			
49	Storage	high	0.1	> 8 hrs	
50		low	0.5	<8 hrs	

WA / WTW / WBS / TWS / Water Mains / CC Scenarios / parameters / assumptions / Change log /

7.16 The parameters identify consequences for each of the asset types and the key drivers behind them. There is also a rationale description and a cross-reference to the risk factors used in the MWH tool.

7.17 Within the tool there is a switch to allow drivers to be turned on or off. This can be used to examine the effects of summed or individual consequences, or a combination. For example a user may wish to look at the effect of temperature changes, which causes both supply interruption and a contamination risk by biological growth.

Risk calculation

7.18 A calculation of risk has been developed for each of the key water and wastewater asset types. In general terms the risk calculation follows the format:

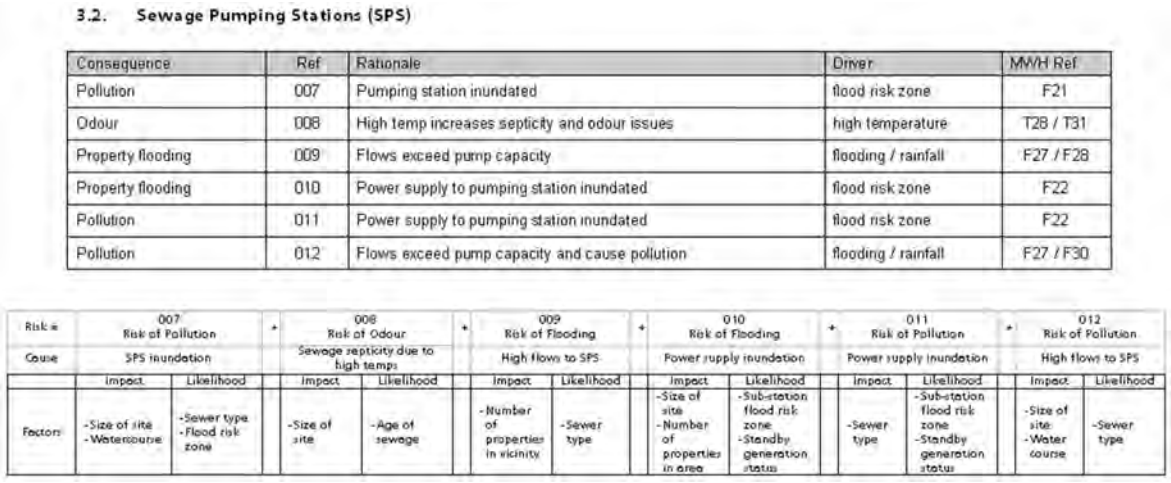
Total risk for asset type = Risk 1 + Risk 2 + Risk 3.

7.19 With each risk being calculated using the principle of:

Risk = Likelihood x Impact

7.20 The likelihoods have been assessed by looking at characteristics of the asset type, for example whether it is in 'Flood Zone 1' or 'Flood Zone 2' or whether customers fed by the asset can be rezoned or not. Figure 7.2 'Risk and consequence calculation for SPS' shows a culmination of parameters identified, with their drivers, and their risk calculation from the likelihoods and impacts.

Figure 7.2 Risk and consequence calculation for SPS



3.2. Sewage Pumping Stations (SPS)

Consequence	Ref	Rationale	Driver	MWH Ref
Pollution	007	Pumping station inundated	flood risk zone	F21
Odour	008	High temp increases septicity and odour issues	high temperature	T28 / T31
Property flooding	009	Flows exceed pump capacity	flooding / rainfall	F27 / F28
Property flooding	010	Power supply to pumping station inundated	flood risk zone	F22
Pollution	011	Power supply to pumping station inundated	flood risk zone	F22
Pollution	012	Flows exceed pump capacity and cause pollution	flooding / rainfall	F27 / F30

Risk =	007 Risk of Pollution		+ 008 Risk of Odour		+ 009 Risk of Flooding		+ 010 Risk of Flooding		+ 011 Risk of Pollution		+ 012 Risk of Pollution	
Cause	SPS inundation		Sewage septicity due to high temps		High flows to SPS		Power supply inundation		Power supply inundation		High flows to SPS	
	Impact	Likelihood	Impact	Likelihood	Impact	Likelihood	Impact	Likelihood	Impact	Likelihood	Impact	Likelihood
Factors	-Size of site -Watercourse	-Sewer type -Flood risk zone	-Size of site	-Age of sewage	-Number of properties in vicinity	-Sewer type	-Size of site -Number of properties in area	-Sub-station flood risk zone -Standby generation status	-Sewer type	-Sub-station flood risk zone -Standby generation status	-Size of site -Water course	-Sewer type

7.21 Figure 7.3 'WwTW screen shot from the tool' is an illustration of the tool's output.

Figure 7.3 WwTW screen shot from the tool

Waste Water Treatment Works

2060

Max	95%	2%	92%	93%	25%	
Ave	27%	0%	34%	34%	5%	
Min	0%	0%	0%	0%	0%	

Driver	FRZ	FRZ	Drought	High Temp	High Temp
Switch (1 / 0)	1	1	1	1	1

Size	Site Flood Risk Zone	SS Flood Risk Zone	Age of sewage	Grade of receiving water	% aeration	Standby Generator	Count of assets within category	compliance 1 (inundation)	pollution 2 (SS inundation)	pollution 4 (low flow)	odour (high temp)	propex (high temps)	Total Baseline Risk	Category Risk	Emission Scenario		
															Low 50%	Med 50%	High 50%
>50,000pe	3	3	>24hrs	2	>50%	No	0	5	0	3.4	4.4	0.6	13	0	121	183	238
>50,000pe	3	1	>24hrs	1	>50%	yes	0	5	0	3.4	4.4	0.6	13	0	121	183	238
>50,000pe	3	2	>24hrs	3	>50%	No	0	5	0	1.5	4.4	0.6	12	0	119	181	236
>50,000pe	3	3	12-24hrs	2	>50%	No	0	5	0	3.4	2.2	0.6	11	0	105	163	216
>50,000pe	3	1	12-24hrs	1	>50%	yes	0	5	0	3.4	2.2	0.6	11	0	105	163	215
>50,000pe	3	3	<12 hours	2	>50%	No	0	5	0	3.4	0.22	0.6	9	0	91	145	195
>50,000pe	3	2	<12 hours	1	>50%	yes	0	5	0	3.4	0.22	0.6	9	0	91	145	195
>50,000pe	3	3	12-24hrs	3	>50%	No	0	5	0	1.5	2.2	0.6	9	0	103	161	213
>50,000pe	3	1	>24hrs	2	30% - 50%	No	0	5	0	1.7	4.4	0.3	11	0	89	129	160
2,000 - 50,000pe	2	3	12-24hrs	1	>50%	No	0	0	0	3.4	0.35	0.2	4	0	29	44	62
2,000 - 50,000pe	2	3	<12 hours	1	>50%	No	0	0	0	3.4	0.035	0.2	4	0	27	42	59
2,000 - 50,000pe	2	1	<12 hours	1	>50%	yes	0	0	0	3.4	0.035	0.2	4	0	26	41	59
2,000 - 50,000pe	2	2	>24hrs	3	>50%	No	0	0	0	0.5	0.7	0.2	2	0	28	44	62
2,000 - 50,000pe	2	3	>24hrs	3	>50%	yes	0	0	0	0.5	0.7	0.2	2	0	28	44	62
2,000 - 50,000pe	2	2	>24hrs	1	30% - 50%	No	0	0	0	1.7	0.7	0.1	3	0	19	28	38
2,000 - 50,000pe	2	1	>24hrs	1	30% - 50%	yes	0	0	0	1.7	0.7	0.1	3	0	19	28	38
2,000 - 50,000pe	2	3	>24hrs	2	<30%	yes	0	0	0	0.075	0.7	0.01	1	0	8	11	14
2,000 - 50,000pe	2	3	>24hrs	3	<30%	No	0	0	0	0.025	0.7	0.01	1	0	8	11	14
<2,000pe	2	3	12-24hrs	3	>50%	yes	0	0	0	0.5	0.25	0.05	1	0	8	13	17
<2,000pe	2	3	<12 hours	1	>50%	No	0	0	0	0.5	0.025	0.05	1	0	7	11	15
<2,000pe	2	3	>24hrs	1	<30%	yes	0	0	0	0.025	0.5	0.0025	1	0	5	6	7
<2,000pe	2	3	12-24hrs	2	30% - 50%	yes	0	0	0	0.25	0.25	0.025	1	0	6	8	11
<2,000pe	2	1	12-24hrs	3	30% - 50%	yes	0	0	0	0.25	0.25	0.025	1	0	6	8	11
<2,000pe	1	1	>24hrs	3	>50%	No	0	0	0	0.5	0.5	0.05	1	0	9	14	19
<2,000pe	1	2	12-24hrs	2	<30%	No	0	0	0	0.025	0.25	0.0025	0	0	2	3	4
<2,000pe	1	3	<12 hours	1	<30%	No	0	0	0	0.025	0.025	0.0025	0	0	1	1	2
<2,000pe	1	2	<12 hours	2	<30%	No	0	0	0	0.025	0.025	0.0025	0	0	1	1	2
<2,000pe	1	1	<12 hours	1	<30%	yes	0	0	0	0.025	0.025	0.0025	0	0	1	1	2

Summary | WWTWs | SPS | STC | Sewers | CC Scenarios | parameters | assumptions | Change log

Consideration of climate change within the tool

7.22 The climate change element of the tool is based upon a set of climate change scenarios, constructed from the new UKCP09 data. We used this data in conjunction with the UKCIP weather generator and threshold detector to feed climate risk into our tool. To ensure we were using their data appropriately we discussed the approach with UKCIP who confirmed the robustness of our tool and the methodology.

> *"We enjoyed having the opportunity to discuss with Anglian Water aspects of their proposed approach to identifying climate risks. I believe that these discussions and the opportunities they afforded to inform the subsequent analysis has put Anglian Water in a good position in terms of understanding climate risks".*
>
> Technical Director, UKCIP

7.23 Our policy has always been to assess risk across the three emission scenarios. When using the new UKCP09 scenarios our preference was to use the 10% probability low, 50% probability medium and the 90% probability high to give the widest reasonable range. UKCIP agreed with this approach, however limitations in the weather generator meant that we could obtain outputs only for the 50% probability for each scenario.

7.24 We used the weather generator to run projections for a selection of criteria we needed to test including area, time slice, duration of run, emissions scenario and amount of samples (random or chosen). This supplied the raw data to which we applied the threshold detector. The outputs of this were then used to generate a multiplier for the chosen climatological parameter, for example 'daily mean temperature'. The multiplier is calculated by dividing the future output by the baseline output.

7.25 In order to obtain the operational thresholds for our assets we canvassed expert opinion from relevant business units. It became apparent early on that there was little evidenced work on thresholds, so the business unit experts were asked for high level estimates. It is acknowledged within the tool that these thresholds need further refinement. Table 7.2 'Climate change thresholds and their multipliers, from baseline to future' shows the thresholds identified within the business compared to the actual threshold used on the UKCIP data, along with their multipliers calculated from the baseline. There are a number of differences between the thresholds identified and those used owing to limits in the current functionality of the threshold detector.

Table 7.2 Climate change thresholds and their multipliers, from baseline to future

Identified threshold within business	UKCIP threshold used	Emissions scenario	2000[1] (baseline)	2020 (multiplier)	2040 (multiplier)	2060 (multiplier)	2080 (multiplier)	2100[2] (multiplier)
Temperature: aeration processes on our WwTW are affected by a diurnal mean temperature of 25ºC or more for at least two days in a row	Number of occurrences of diurnal mean temperature >24.9ºC for a minimum of two days in a row	Low	1.0	17.1	57.1	100.5	180.5	200.0
		Medium	1.0	25.3	81.6	173.6	380.0	450.0
		High	1.0	14.4	95.2	252.5	537.3	800.0
Temperature: odour from our wastewater assets is increased by mean diurnal temperature exceeding 20ºC	Number of occurrences of diurnal mean temperature >19.9ºC for exactly one day	Low	1.0	3.8	5.8	7.1	8.6	10.4
		Medium	1.0	4.2	6.2	9.1	12.4	16.0
		High	1.0	3.6	6.6	10.2	14.1	19.0
Rainfall: low flows in sewers and rivers, based on less than average rainfall, will cause an increase in concentration of sewage treated and effluent	Number of occurrences of days with precipitation rate <1.52mm/day (1.52mm calculated as average from baseline of weather generator data)	Low	1.0	1.03	1.04	1.06	1.07	1.08
		Medium	1.0	1.04	1.07	1.09	1.10	1.11
		High	1.0	1.03	1.05	1.09	1.11	1.15
Flooding: the flood zone an asset sits within causes a different risk of flooding. Anything within Flood Zone 3 has the highest risk of flooding	Number of occurrences of days with precipitation rate >67.5 mm/day. This is the value of a 1 in 50 year storm return period calculated from the FEH	Low	1.0	12.0	36.0	12.0	12.0	24.0
		Medium	1.0	48.0	24.0	12.0	12.0	24.0
		High	1.0	1.0	12.0	24.0	48.0	48.0

Identified threshold within business	UKCIP threshold used	Emissions scenario	2000[1] (baseline)	2020 (multiplier)	2040 (multiplier)	2060 (multiplier)	2080 (multiplier)	2100[2] (multiplier)
Flooding: the flood zone an asset sits within causes a different risk of flooding. Flood Zone 2 is the middle boundary	Number of occurrences of days with precipitation rate >114.3 mm/day. This is the value of a 1 in 500 year storm return period calculated from the FEH	Low	1.0	24.0	12.0	18.0	18.0	24.0
		Medium	1.0	18.0	36.0	18.0	42.0	42.0
		High	1.0	18.0	30.0	30.0	42.0	42.0
Flooding: the flood zone an asset sits within causes a different risk of flooding. Anything within Flood Zone 1 has the lowest risk of flooding	Number of occurrences of days with precipitation rate >133.9 mm/day. This is the value of a 1 in 1000 year storm return period calculated from the FEH	Low	1.0	5.3	6.1	5.1	6.9	7.9
		Medium	1.0	4.8	6.9	7.0	8.3	9.4
		High	1.0	5.3	6.4	7.5	9.5	11.1

1. The baseline frequency of events have been allocated a likelihood of 1.0.
2. 2100 figures are an estimation based on trend analysis of the 2020 - 2080 outputs.

Uncertainties

7.26 As can be seen from Table 7.2 'Climate change thresholds and their multipliers, from baseline to future' there are a number of non-linear series in the multipliers. These could be explained by:

- the general uncertainty with climate change scenario projections
- the fact that the three emissions scenarios do not diverge greatly until 2040
- the fact that the impacts of both the low and medium emissions scenarios exceed the high scenario in the early decades.

7.27 This is just one of the many assumptions, uncertainties, barriers or knowledge gaps that we experienced during the creation of this tool. Four of the most important are:

- limitations of the weather generator and threshold detector, for example the inability to choose a desired probability within the scenario you wish to use
- lack of agreed knowledge on asset operation thresholds
- assumptions regarding the cost of the impact on the business area and the likelihoods
- mismatches between UKCP09 outputs and the data format required by us, causing the use of surrogates. For example flood risk assessment should not only take account of amount of rain but also catchment characteristics, intensity and duration of rain, or previous days' weather. However the only output available from UKCIP is amount of rain, therefore this was the surrogate. These are shown in Table 7.2 'Climate change thresholds and their multipliers, from baseline to future'.

7.28 When using this tool it is necessary to understand that it is identifying only high level trends in how asset types may react to climate change. At this time the new tool does not give risk scores for a specific single asset, but the trends identified will be used to target more detailed investigations and these will then be used to inform investment plans. The effectiveness of the tool will be regularly monitored and a project has already been initiated to review and improve our understanding the thresholds and to undertake further verification (listed in our programme of measures).

Outputs of the new risk assessment

7.29 The outputs from our new risk tool give a indication of the areas of our business that different climate change drivers may affect. The tool has the capability to assign risk to a specific asset type depending on its characteristics including size, flood risk zone and grade of receiving water. However, the tool needs further validation before we can use it at a specific individual asset level to directly influence business case investments. Currently the tool highlights the changing trends in economic risk for asset types for either one consequence of climate change, a group with the same driver or cumulatively for all implications of climate change within the risk tool. Whilst detailed individual projects will be necessary to support business cases, an initial trend analysis for each individual consequence has been done by asset type. The results of this are detailed in the paragraphs below.

7.30 Table 7.3 'Outputs from new risk tool' provides a summary of the cumulative risks for each asset type from both the water and wastewater elements, showing their change in risk over the coming years and for the different emissions scenarios.

Table 7.3 Outputs from new risk tool

Asset type	Emissions scenario	Risk for each time period (£'000)(1)					
		2000	2020	2040	2060	2080	2100
Large WwTW	Low	13	57	94	121	185	209
	Medium	13	62	115	183	328	392
	High	13	55	122	238	436	624
Medium WwTW	Low	6	17	27	36	55	62
	Medium	6	18	34	55	100	118
	High	6	16	36	72	134	193
Small WwTW	Low	2	6	10	12	18	20
	Medium	2	7	12	18	31	37
	High	2	6	12	23	40	57
Large SPS	Low	129	676	784	666	896	1028
	Medium	129	616	886	911	1087	1240
	High	129	675	825	978	1244	1464
Medium SPS	Low	65	344	397	333	450	516
	Medium	65	312	449	457	543	616
	High	65	344	417	490	621	728
Small SPS	Low	13	70	82	69	93	107
	Medium	13	64	92	95	113	129
	High	13	70	86	102	130	153
Sludge Treatment Centre (STC)	Low	29	111	159	183	224	269
	Medium	29	118	172	236	315	399
	High	29	107	178	263	358	473
Large Water Abstraction (WA)	Low	10	53	61	51	69	79
	Medium	10	48	69	70	83	94
	High	10	53	64	75	95	111
Medium WA	Low	3	16	18	15	21	24
	Medium	3	14	21	21	25	28
	High	3	16	19	23	29	33
Small WA	Low	1	4	5	4	6	6
	Medium	1	4	6	6	7	8
	High	1	4	5	6	8	9
Large WTW	Low	28	176	334	467	777	868
	Medium	28	193	430	742	1454	1710
	High	28	167	464	1009	1989	2882
Medium WTW	Low	8	44	72	90	143	160
	Medium	8	45	88	136	246	288

Asset type	Emissions scenario	Risk for each time period (£'000)(1)					
		2000	2020	2040	2060	2080	2100
	High	8	43	92	176	328	464
Small WTW	Low	2	13	22	29	48	54
	Medium	2	13	28	46	86	101
	High	2	12	30	61	117	168
Large Water Boosting Site (WBS)	Low	7	34	42	40	54	62
	Medium	7	31	47	51	62	71
	High	7	34	44	53	69	80
Medium WBS	Low	3	12	15	15	20	23
	Medium	3	11	16	18	23	26
	High	3	12	15	19	25	29
Small WBS	Low	1	3	4	4	5	6
	Medium	1	3	4	5	6	7
	High	1	3	4	5	7	8
Large Treated Water Storage (TWS)	Low	134	690	886	875	1291	1460
	Medium	134	630	982	1103	1459	1640
	High	134	690	922	1163	1603	1844
Medium TWS	Low	20	92	124	131	198	223
	Medium	20	85	136	159	219	245
	High	20	92	129	167	237	271
Small TWS	Low	7	36	45	43	62	71
	Medium	7	33	50	55	71	80
	High	7	36	47	58	79	91
Large water mains	Low	18	58	158	267	467	516
	Medium	18	79	220	450	967	1142
	High	18	51	254	648	1360	2017
Medium water mains	Low	8	16	36	58	98	108
	Medium	8	20	49	95	198	233
	High	8	15	55	134	277	409
Small water mains	Low	2	4	8	12	20	22
	Medium	2	5	10	20	40	47
	High	2	4	12	27	56	82

1. The values in this table are the highest recorded results for each asset type and scenario combination.

7.31 These outputs show trends which generally agree with those from our previous risk assessment and support our current priorities. For example, a major early-onset driver identified in both risk assessments was fluvial and coastal flooding of water and wastewater assets. This was was a focus of our AMP5 submission (see Case Study 5).

New conclusions

7.32 To better illustrate the general trends of impact, and identify new conclusions for addition to our full programme of measures (a selection of which are in Table 6.3 'Programme of measures key actions'), more detailed analysis of the results for individual consequences has been carried out. The results, as seen in Figures 7.4 -7.11,show that the trends for each consequence all increase. However certain consequences, driven by different climatological effects increase substantially more than others. These are indicated in Table 7.4 'The consequences for each asset type, their drivers and key risks'.

Table 7.4 The consequences for each asset type, their drivers and key risks

Asset type	Consequence	Driver	Analysis of most substantial consequences(1)
WwTW	Compliance failure	Site inundation due to fluvial and coastal flooding depending on which flood zone it is in	The most substantial consequence is an **increase in propex** expenditure due to the failure of our aeration plants in **high temperature weather**. Although this consequence increases sharply above all others this is only from 2040 onwards (see Figure 7.11 'Risk scores of each consequence affecting individual WwTW'). Currently the most substantial consequence is **compliance failure** from site inundation owing to **fluvial and coastal flooding**. This supports our FBP proposals for fluvial and coastal flooding protection at WwTW. Details are in Case Study 5.
	Pollution incident	Sub-station inundation due to fluvial and coastal flooding depending on which flood zone it is in	
	Pollution incident	An increase in effluent strength owing to low flow as a result of a decrease in rainfall	
	Increase in odour	Elevation of smell owing to high temperature threshold being exceeded	
	Increase in propex	Aerated processes require extra dissolved oxygen owing to high temperature threshold being exceeded	
SPS	Pollution incident	Site inundation owing to fluvial and coastal flooding depending on which flood zone it is in	For SPS the most substantial consequence is **property flooding when a site's capacity is overwhelmed**. This is taken to be **a greater than 1:50 storm return event**. (see Figure 7.4 'Risk scores of each consequence affecting individual SPS'). This trend increase is vast compared to the other consequences probably due to the low threshold and the high costs associated with property flooding. This relationship needs further study
	Pollution incident	Sub-station inundation owing to fluvial and coastal flooding depending on which flood zone it is in	
	Property flooding	Flows exceeding pump capacity owing to increased flooding / rainfall	
	Property flooding	Sub-station inundation owing to which flood zone it is in, causing the site to fail and overflow	
	Increase in odour	Elevation of smell due to high temperature threshold being exceeded	
	Pollution incident	Flows exceeding pump capacity owing to increased flooding / rainfall	

Asset type	Consequence	Driver	Analysis of most substantial consequences(1)
STC	Increase in propex	Extra tankering costs owing to inundation of connecting roads from increased flooding / rainfall	**Increase in odour** owing to **high temperature weather** is the most substantial consequence (see Figure 7.5 'Risk scores of each consequence affecting individual STC'). As STC are limited in their range of operations other consequences are far less likely and the implications lower
	Increase in propex	Extra tankering costs owing to inundation of agricultural land from increased flooding / rainfall	
	Increase in odour	Elevation of smell owing to high temperature threshold being exceeded	
	Increase in propex	Site inundation owing to fluvial flooding depending on which flood zone it is in	
	Increase in propex	Increase in effluent concentration owing to low flow as a result of a rainfall decrease	
WA	Supply interruption	Site inundation owing to fluvial and coastal flooding depending on which flood zone it is in	Both site and sub-station inundation from **fluvial and coastal flooding** are the most substantial consequences, causing equal **interruption to supply** (see Figure 7.8 'Risk scores of each consequence affecting individual WA sites')
	Supply interruption	Sub-station inundation owing to fluvial and coastal flooding depending on which flood zone it is in.	
WTW	Supply interruption	Site inundation owing to fluvial and coastal flooding depending on which flood zone it is in	Currently the most substantial consequence is **supply interruption** from site inundation by **fluvial and coastal flooding**. This supports our AMP5 fluvial and coastal flood protection programme. After 2020 **contamination risk** from raw water deterioration causes the most substantial consequence (see Figure 7.9 'Risk scores of each consequence affecting individual WTW'). This is a result of **high temperature weather**. Details are in Case Study 5.
	Supply interruption	Sub-station inundation owing to fluvial and coastal flooding depending on which flood zone it is in.	
	Supply interruption	Site cannot meet demand owing to a temperature increase	
	Contamination risk	Increase in biological growth owing to high temperature threshold being exceeded	
	Increase in propex	Failure of equipment owing to high temperature threshold being exceeded.	
WBS	Supply interruption	Site inundation owing to fluvial and coastal flooding depending on which flood zone it is in	**Supply interruption** from site inundation owing to **fluvial and coastal flooding** causes the most substantial consequence (see Figure 7.6 'Risk scores of each consequence affecting individual WBS')
	Supply interruption	Sub-station inundation owing to fluvial and coastal flooding depending on which flood zone it is in	
	Supply interruption	Site cannot meet demand owing to a temperature increase	

Asset type	Consequence	Driver	Analysis of most substantial consequences(1)
TWS	Supply interruption	Site cannot meet demand owing to a temperature increase	**Contamination risk** due to site inundation from **fluvial and coastal flooding** causes the most substantial consequence (see Figure 7.7 'Risk scores of each consequence affecting individual TWS sites')
	Contamination risk	Bacterial regrowth owing to high temperature threshold being exceeded	
	Contamination risk	Site inundation owing to fluvial and coastal flooding depending on which flood zone it is in	
Water mains	Contamination risk	Bacterial regrowth owing to high temperature threshold being exceeded	**Contamination risk** from bacterial regrowth is the most substantial consequence (see Figure 7.10 'Risk scores of each consequence affecting individual water mains'). This is caused by **high temperature weather**
	Supply interruption	Site cannot meet demand owing to a temperature increase	
	Supply interruption	Change in soil moisture owing to low flow and site infrastructure breakage	

1. Bold designates the primary impacts and drivers

7.33 Plotting the outputs of these individual consequences, for each asset type, has corroborated the conclusions of our first risk assessment. However they do also indicate that there are a number of previously unidentified trends that merit further research. An example of this is that SPS may carry a much higher climate related business risk than WwTW, which have been the focus to date.

7.34 The following graphs illustrate the individual consequences and their trends for all asset types within the risk assessment tool(1).

1 Values taken for the consequences are the highest recorded for the 50% probability, medium emissions scenario, for large sites where applicable

Figure 7.4 Risk scores of each consequence affecting individual SPS

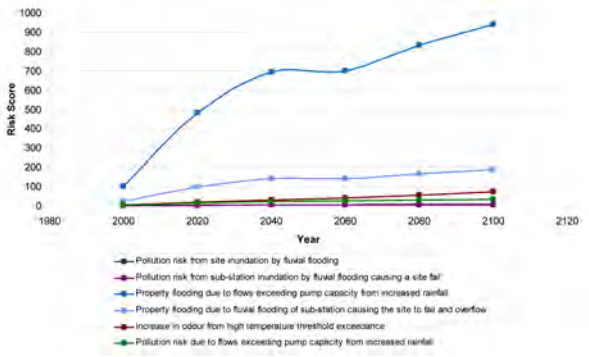


Figure 7.5 Risk scores of each consequence affecting individual STC

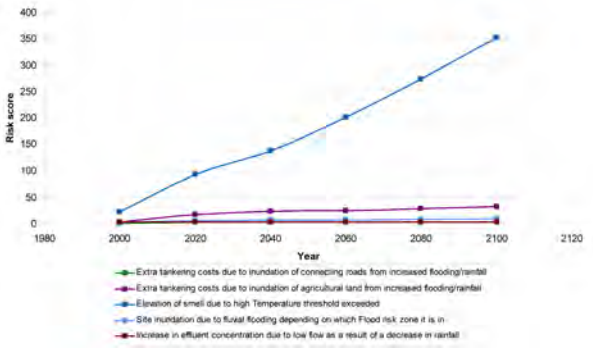


Figure 7.6 Risk scores of each consequence affecting individual WBS

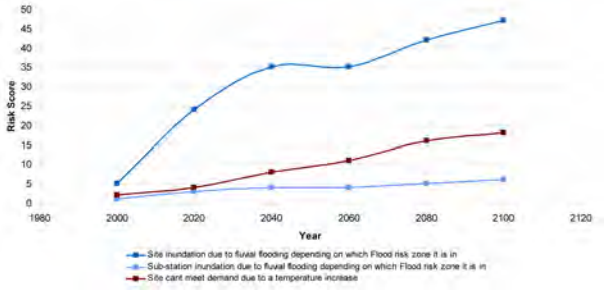


Figure 7.7 Risk scores of each consequence affecting individual TWS sites

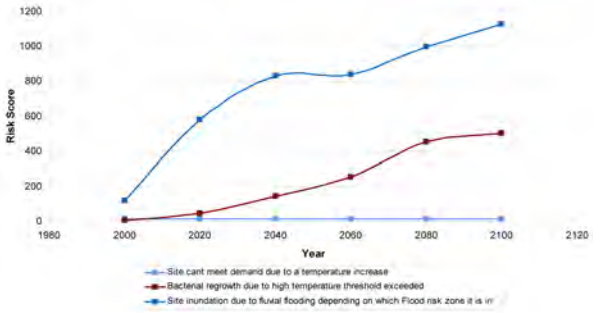


Figure 7.8 Risk scores of each consequence affecting individual WA sites

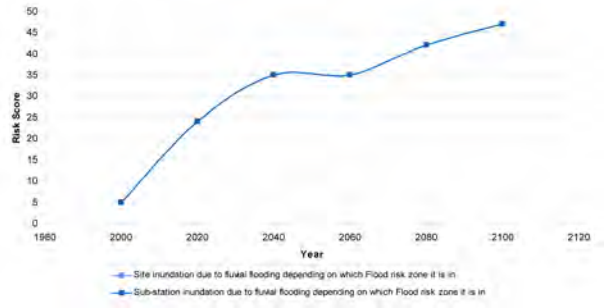


Figure 7.9 Risk scores of each consequence affecting individual WTW

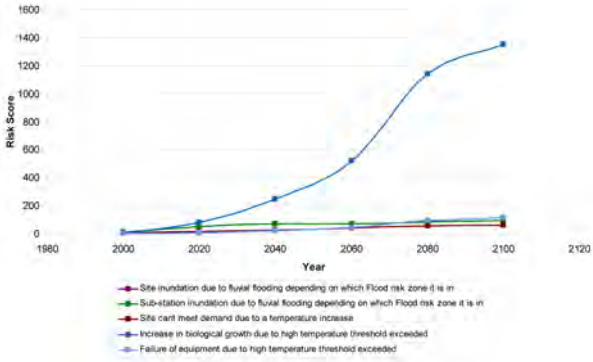


Figure 7.10 Risk scores of each consequence affecting individual water mains

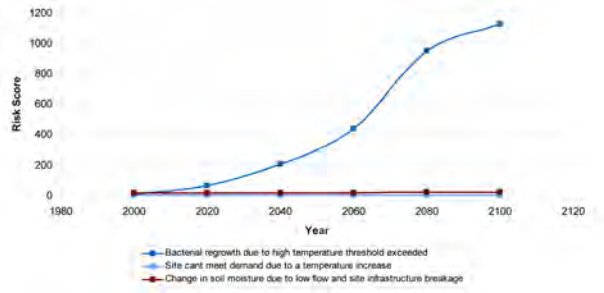
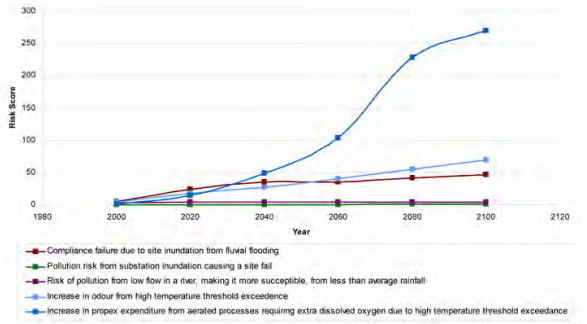


Figure 7.11 Risk scores of each consequence affecting individual WwTW



7.35 In addition, this analysis has identified the following general trends:

- a given climate driver can result in different consequences depending on the asset type that it affects
- even when the consequence is the same across asset types the financial risk can vary substantially owing to the business impact.

7.36 These demonstrate the fact that detailed work on a case by case basis is necessary to make investment decisions. Although produced in tandem with this report, this tool is designed for continued and more detailed use within the business through our coming AMP periods. This will require ongoing review, and validation in partnership with our R and V and Asset Creation teams. This will ensure its appropriate use in future planning and solutions to specific business cases. Section 9 details how these teams fit into our review process. Further analysis of the outputs of the new risk assessment are included as actions in our programme of measures (a selection is shown in Table 6.3 'Programme of measures key actions').

7.37 The new risk assessment supports and corroborates the risks, drivers and consequences identified through our previous risk assessment. Table 7.5 'Top risks to the company identified from both of our risk assessments' uses the outputs of our new tool and the outputs of our original risk assessment to identify the top 10 climate change risks to our company.

Table 7.5 Top risks to the company identified from both of our risk assessments

Risk	Effect	Thresholds	Risk score	Consequences	Time frame[1]	Action	CBA	Residual risk
Climate change	See risk assessments	Various	Top in company risk register	Inability to deliver statutory functions	Short-term	Establishing climate change team and corporate governance	See individual risks	See individual risks
Fluvial and coastal flooding of WwTW	Site inundation	Table 7.2 'Climate change thresholds and their multipliers, from baseline to future'	See Figure 7.11 'Risk scores of each consequence affecting individual WwTW'	Compliance risk	Short-term	Flood prevention and protection	In FBP(LINK)	In FBP(LINK)
Elevated temperature on WwTW	Process failure			Compliance risk	Medium-term	Innovation research and design project	N/A	N/A
Extreme rainfall on SPS	Asset failure		See Figure 7.4 'Risk scores of each consequence affecting individual SPS'	Property flooding	Short-term	Investment to remove priority properties from risk register	In FBP(LINK)	In FBP(LINK)
Elevated temperature on STC	Increased odour		See Figure 7.5 'Risk scores of each consequence affecting individual STC'	Abatement notices	Short-term	Climate change to be considered in Biosolids strategy review	N/A	N/A
Fluvial and coastal flooding on water sites	Site inundation		See Figures 7.4 - 7.11	Supply interruption and contamination	Short-term	Investment for flood prevention and protection	In FBP(LINK)	In FBP(LINK)
Elevated temperature on WTW	Raw water quality deterioration		See Figure 7.9 'Risk scores of each consequence affecting individual WTW'	Increased treatment costs	Medium-term	Innovation research and design project	N/A	N/A
Sea level rise	Coastal erosion and inundation and saline intrusion	See Section 5	High	Temporary or permanent asset loss	Medium to long-term	Internal analysis and input into SMP process	N/A	Undetermined
Precipitation and temperature changes	Changes in water resources availability	See WRMP 2010	See WRMP 2010	Reduction in DO	Medium-term	None to date but to review WRMP	See WRMP 2010	See WRMP 2010
Extreme rainfall - sewer capacity	Sewer capacity exceeded	Increase in frequency	Medium	Property flooding	Short-term	Innovation research and design project	N/A	N/A

1. Short-term= up to 2030, medium-term = 2030 - 2060 and long-term = beyond 2060.

8 Assumptions, uncertainties, barriers and interdependencies

Key messages

1. A large number of uncertainties, assumptions, barriers and knowledge gaps have been identified prior to and during the production of this report.
2. Climate change uncertainty itself, is one of the biggest challenges when projecting risks and adapting to them.
3. The current regulatory structure is a good mechanism for allowing the delivery of adaptation. The few barriers associated with it are those of understanding and communication between the stakeholders.
4. We cannot adapt in isolation as we have many interdependencies.
5. Funding changes affecting the delivery of key third-party activities on which we rely, such as flood defence, can have a major impact on our ability to adapt.

Introduction

8.1 We have been liaising with our regulators, other key stakeholders and specialists, such as UKCIP, for more than a decade on climate change issues. Through this process we have identified the barriers, uncertainties, assumptions and interdependencies that affect us. In early phases, issues such as a lack of climate change knowledge, understanding and belief were the main barriers. As our level of understanding has increased, the issues that we are encountering are more focused on specifics such as particular data gaps or regulatory instruments.

8.2 The issues identified reside in a many locations in the process including within our company, our regulators, wider society, suppliers, and the modelling and research community. They range from large and generic (uncertainty: which emissions scenario will come to pass?) down to very specific (knowledge gap: what temperature over what duration causes problems with aerated sludge plants?). However in our analysis they can broadly be attributed to the following five categories:

- external knowledge gaps
- internal knowledge gaps
- regulatory issues
- societal factors
- interdependencies.

8.3 We have analysed all of the issues identifying the type, what we have done to accommodate it, who we feel is responsible for resolving the issue and what outputs we would like to see from their intervention. The rest of this section gives some examples of how we have dealt with these issues and indicates those that we see as our priority.

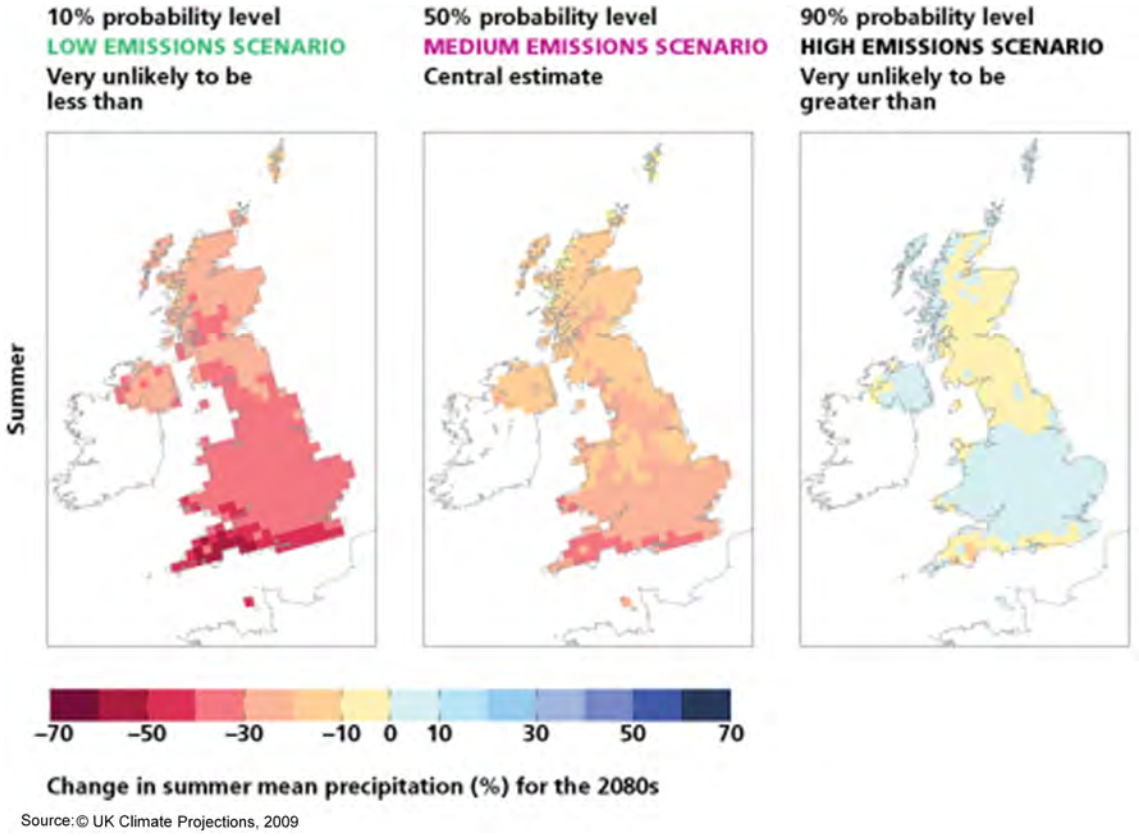
External and internal knowledge gaps

8.4 A large number of the external knowledge gaps can be attributed to climate change data itself, as it has intrinsic uncertainties. Any action taken to tackle climate change is therefore inevitably going to have an inherent level of uncertainty attached (see Figure 8.1

'UKCP09 wide range projections of UK summer mean precipitation change in 2080'). At an overview level, uncertainty in the projections of future climate change arises from three causes:

- natural climate variability regardless of any human influence
- modelling uncertainty owing to incomplete understanding of Earth system processes and their imperfect representation in climate models
- uncertainty in future man-made emissions of greenhouse gases and other pollutants.

Figure 8.1 UKCP09 wide range projections of UK summer mean precipitation change in 2080



Source: © UK Climate Projections, 2009

8.5 In addition to the inherent uncertainties within climate science the UKCP09 projections also contain a number of significant assumptions including:

- all scenarios assume no political action to reduce emissions in order to mitigate climate change
- sea level rise is based purely on thermal expansion of the existing water volume and the general scenarios do not include ice melt.

8.6 Flexibility is key to dealing with climate change and these issues should not be used as barriers to successful adaptation. They should be seen as a series of parameters that any solution or decision making process should be flexible enough to accommodate. Achieving this balance helps to avoid implementing actions which may become maladaptation should the projected future change.

8.7 Other significant external knowledge gaps that do not relate to climate change science include:

- lack of clarity from the SMP process relating to the footprints of future proposed coastal retreat
- our risk tool does not currently encompass all of our business activities, however improvement of the tool is within our programme of measures
- uncertainty over what changes there may be in demand for water and biosolids in the food production and processing industries.

8.8 A significant proportion of the internal and external knowledge gaps have been discovered when we have attempted to apply the accepted climate change data to our processes and assets in order to understand the impacts. The two main reasons for this are that the:

- questions have not been asked before, so the data has not been collated by our business or others
- data is collected for other purposes so it is in an incomplete or incompatible format.

The regulatory landscape

8.9 Competition and market reform could have a significant impact on the regulatory landscape within which we operate and the incentives and focus on addressing climate change risks and adaptation. For the purposes of this report we have assumed that the current regulatory regime will continue to be in operation for the foreseeable future as this allows climate change impacts on our company to be assessed over the long term in line with the lifespan of some of our assets. We are aware that this is an assumption, so we have ensured that the governance and review processes that are built into our business (see Section 9) will ensure that our plans are flexible and able to take future changes into account.

8.10 Our assessment of the regulatory issues, arising from our efforts to integrate climate change adaptation into our business, has indicated that barriers occur as a result of existing regulation implementation or uncertainties regarding potential future changes. These can both result in assumptions in order to accommodate or overcome them.

8.11 The responsibility for funding the maintenance of coastal defences are a case in point. If changes are made to the current mechanism for funding the management of these assets, and third parties that receive protection from the defences are required to make contributions to their upkeep, then this must be reflected in how our price limits are set in the future.

8.12 Other significant issues include:

- conflict between our adaptation requirements and our regulators' interpretation. For example the investment approved for fluvial and coastal flooding alleviation for our wastewater assets
- many current and new regulations do not incorporate adaptation, do not allow sustainable adaptation or are at odds with climate change targets
- the indirect effect that changes in the funding levels of our regulators may have on us, such as the availability of data, provision of models and advice (for example flood models or the impacts of climate change on SSSI).

Societal issues

8.13 A significant number of issues that can influence the direction and viability of our adaptation strategy and actions can be attributed to the beliefs and behaviours of the society within which we operate. The basis for many of these actions revolve around personal choice and they can therefore be very difficult to deal with or manage. Although there are a number of issues that affect us, three of the most important are:

- consumers do not understand the true value of water
- many consumers view the subject of climate change with varying degrees of scepticism
- our customers' priorities on their Willingness To Pay (WTP) for adaptation.

8.14 Customers' WTP can be heavily influenced by the issues of valuing water and degrees of scepticism and can in turn, impact on the valuation of projects within our investment decisions. In order for us and others to be able to appropriately discuss adaptation measures with customers, many agencies involved with climate change need to work together in ensuring that society has access to the best information available.

8.15 In addition to the above a number of other issues exist, including:

- uncertainty over what changes in water demand we may see owing to water efficiency, growth or climate induced change
- the effects of the economic cycle.

Priority Issues

8.16 Whilst these are some of the key issues that can affect our ability to adapt, this is only a small selection of those that we have identified. These issues vary in urgency and complexity, but we have used our CCSG to identify the priority issues. These are listed in no particular rank in Table 8.1 'Our top 15 priorities to overcome'[(1)].

1 Words in bold are defined as key

Table 8.1 Our top 15 priorities to overcome

Category	Statement	Result	Our actions and rationale	Owner	Comments
External knowledge gap	Climate change is a cutting edge discipline and there are uncertainties in the projections. However the current projections are the best available science	**Assumption** Barrier **Uncertainty**	We have used the best available data and acknowledged the limitations. There is nothing we can do to eliminate uncertainty in the source data	**Meteorological Office** **UKCIP** **Tyndall Centre** **Hadley Centre** **Walker Institute** **Grantham Institute** **Defra** **Research and modelling community**	Regular review of our risk assessment and tools to reflect the best available data Greater involvement with UKCIP in practical use of data & tools and scenario user guidance Periodic revision of data sets ensuring that scenarios reflect changes in data and science (updates beyond UKCP09) Research to provide greater flexibility and knowledge relating to spatial and seasonal variations
External knowledge gap	Uncertainty over which emissions scenario to use as there is no correct scenario. All have the same validity	Assumption **Uncertainty**	For our initial risk assessment we have used the low, medium and high emissions scenarios. Further work will identify the most appropriate one on a case by case basis depending on the risk profile of the activity		
External knowledge gap	Our engagement with our interdependencies on climate change has been limited. We have limited knowledge of their adaptation and make assumptions in our adaptation strategy	**Assumption** **Knowledge gap** **Uncertainty**	We have Identified our key interdependencies and established dialogue with a number of them including Ofwat, water companies and the EA. Currently exploring dialogue with others, including power companies	**Defra** and **DECC** (for UK approach) **Ourselves** and all interdependencies (for local approach)	There should be a coordinated approach locally, regionally & nationally National risk assessment should draw together information from all sectors
External knowledge gap	Lack of national research coordination	Barrier **Knowledge gap**	We have involvement with UKWIR, research councils and have a number of active research collaborations	**Defra** or other national data repository (for example UKCIP or Hadley Centre / Meteorological Office)	Production of a research database / coordination facility

Category	Statement	Result	Our actions and rationale	Owner	Comments
External knowledge gap	Housing growth, population growth, demographic changes and intra-region migration owing to climate impacts such as rising sea levels. These could all influence many operational activities	**Uncertainty**	We have worked closely with planning authorities through Government Offices and Regional Development Agencies to use the best available information at a regional level. We have taken a lead role in establishing a high level group to work with regional assemblies on reviewing regional strategies and worked with local authorities responsible for the delivery of local development framework on water cycle studies. We have also been involved in key local reviews such as those for the SMP	**UK Government** Ofwat Water Companies Public **Defra** **Local Authorities** **Regional Planning Authorities**	Full collaboration on development of legislation Consultative approach to defining areas of predicted growth and loss Early identification of such areas and the impacts for example on the supply / demand balance for future water resource planning
Internal and external knowledge gaps Regulatory Societal	Public acceptance of climate change is varied, with a residual scepticism. Many people also cannot relate it to their individual actions	**Barrier**	Internal education seminars for employees (An Inconvenient Truth for Anglian Water). Supplier engagement events. Customer education and engagement	**All**	Coordination of common messages to create a society open and responsive to the latest climate change science and the need for action
Internal knowledge gap	There are a large number of assumptions within the risk tool. A number of examples are: ● climate change scenario probabilities used ● likelihood estimates ● frequency estimates for impacts ● thresholds relating to asset performance	**Assumption** **Barrier** **Knowledge gap**	Climatological assumptions have been checked with UKCIP Thresholds related asset performance and likelihoods ground-truthed with business unit experts All other assumptions generated with R and V representatives in line with our standard practice	Ourselves UKWIR Research and modelling community Defra (**UKCIP**) for funding and national coordination	Evolution of our tool in response to new data and feedback Internal data validation and external research projects into climate change thresholds on assets

Category	Statement	Result	Our actions and rationale	Owner	Comments
Regulatory	Future changes in regulatory regimes	**Assumption** **Uncertainty**	We have constructed our report based on current legislation as we cannot cover all possible futures We have designed flexible systems that can be reviewed in light of change	**Ofwat** **Defra** **EA** **NE** **DWI** **EU**	Collaboration on generation of legislation Consultative approach to legislative landscape
Regulatory	Availability of third-party funding	**Barrier** **Uncertainty**	Understanding the impact of funding changes for our regulators (and others) and the direct and indirect impacts on us	**UK Government** **All bodies subject to cuts**	Funding at an appropriate level for those services necessary to achieve successful adaptation
Regulatory	There will be no change in the government position on climate change	**Assumption**	As we cannot cover all possible futures we are adapting our company due to the inevitability of climate change. We have therefore constructed our report based on the current position and the effect of policy changes will be reviewed	**UK Government** Other stakeholders (regulators, Non-Governmental Organisations (NGO), Water UK, ourselves)	Continued focus on the twin challenges of mitigation and adaptation We believe there should be parity on the importance placed on adaptation and mitigation in government strategy
Regulatory	There will be no change to the water industry structure	**Assumption**	We are monitoring the ongoing discussions on the future of the water industry structure. Any changes will be fed back into our climate change risk assessment	**UK Government** **Regulators**	The review of the industry structure must ensure that any proposals take account of the need for flexible, timely and sustainable climate change adaptation
Regulatory	Misalignment between us and our regulators on the valuations used for elements of CBA calculation	**Barrier** Knowledge gap	Continuing dialogue with our regulators at a strategic and business case level	**All stakeholders in the Periodic Review process**	Agreement on calculation, use and interpretation of CBA

Category	Statement	Result	Our actions and rationale	Owner	Comments
Regulatory	Lack of flexibility within and conflict between current and new regulations. Many do not incorporate adaptation, do not allow sustainable adaptation or are at odds with climate change targets	**Barrier**	Continued dialogue with regulators and policy makers to ensure future legislation is climate proofed Developed systems to deliver 'least worst' solutions Put systems in place to ensure delivery of most appropriate solution allowable by regulatory restrictions	**Regulators** **EU** **Derfa** Other stakeholders (Confederation of British Industries, NGO, Water UK, ourselves)	We would like to see guidance on how the balance between local quality and global climate issues should be resolved We would like to see a review of existing legislation to ensure that it integrates climate change New legislation should take account of and consider its impact on adaptation
Regulatory	Conflict between our adaptation requirements and our regulator's stance such as on fluvial and coastal flooding of wastewater assets and changes to sewer design standards	**Barrier** Knowledge gap	Opened dialogue with regulators Review WTP / CBA and use to balance investment For future flooding we are working with the EA to better incorporate environmental benefits	**Ourselves** Stakeholders **Regulators**	Greater recognition from regulators of our need for a longer term view in relation to adaptation planning and expenditure Dialogue relating to balance between affordability and customer and regulator requirements
Societal	Will our customers priorities be the same as ours and will they be willing or able to afford the necessary bill increases?	**Barrier** **Uncertainty**	Extensive surveys and work with Expert Opinion Panels and Consumer Council for Water (CCW) Incorporated WTP into the business plan process and reviewing Modelling for production of the SDS Education of customers through education centres and love every drop	**Ourselves** **CCW** **Ofwat** **EA** **UK Government**	Greater collaboration between all stakeholders to educate the population on the need for adaptation

Interdependencies

8.17 As a geographically and operationally diverse organisation we are dependent on a large number of suppliers and other stakeholders. Collectively this grouping covers a wide range of activities and supplies and for the purposes of our climate change strategy they have been categorised as interdependencies.

8.18 Our Climate Change and Environmental Performance team, SCM team, Business Continuity and Emergency Response (BCER) team and Water and Wastewater Services have identified those suppliers that are business critical. This was defined as either causing an immediate operational issue or requiring a long lead time to replace in the event of service loss. The 'critical' list is as laid out below.

Table 8.2 Key interdependencies

Type	Organisation	Our dependencies on them	Their dependencies on us
Suppliers		Bulk chlorine	Process and domestic water supply if they are our business customers
		Ferric sulphate, polyelectrolytes	
		Orthophosphoric acid	
		Virgin GAC & GAC regeneration	
		Odour control chemical	
		Calcium hydroxide and Calcium oxide (Lime)	
		Emergency bottled water in the event of supply interruption	
Regulators	Defra	Appropriate regulatory environment	Data
	Ofwat	Appropriate regulatory environment, investment approval	Data
	EA	Appropriate regulatory environment for example flood defence, monitoring, modelling, permits	Process and domestic water supply if they are our business customers
	DWI	Appropriate regulatory environment	
	NE	Appropriate regulatory environment, permits	
Power		Electricity generator and distribution	Boiler feed and co-users of river resource if generators in our region
		Electricity generator	

Type	Organisation	Our dependencies on them	Their dependencies on us
		Gas supplier	Domestic water supply if they are our business customers
		Electricity supply	
		Gas distribution	
		Standby power	
		Liquid fuel	
Water companies		Mutual aid agreements Water resources transfer	Mutual aid agreements Water resources transfer
Public sector	Hospitals	Health and safety	Domestic water supply if they are our business customers
	Schools	Education	
	Local Authorities	Flood defence, road maintenance, surface water management	Data and domestic water supply if they are our business customers
	Highways Agency	Road maintenance	
	IDB	Flood defence	
Communications		Mobile communications	Domestic water supply if they are our business customers
		Telemetry	
Agriculture	Farmers	Land bank for biosolids, competition for and diffuse pollution of water resources	Competition for water resources
Other customers	Food producers	Demand changes	Process and or domestic water supply if they are customers
	Domestic		
	Manufacturing		

8.19 The table above is not an exhaustive list of our interdependencies and it represents our first attempt at identifying those that are key to our daily operations. Although the listing is not ranked, it became obvious in the early stages that some interdependencies were more key than others. Two of the most important interdependencies are our regulators, the power sector and other water companies in our region.

Our regulators

8.20 A number of key dependencies are common to them all: we are dependent on them for our regulatory framework and they are dependent on us for data. As we have already stated the most key relationship is with our economic regulator, Ofwat. Our primary route for delivering adaptation action is through the approval of investment through the periodic review process. It is imperative that Ofwat and the industry are able to agree the information that is required in developing robust business cases for adaptation delivery.

8.21 In relation to the EA and Natural England, we also require licences, permits and consents in order to carry out our daily operations. However the EA is our larger dependency as they also perform a much wider set of activities on which we are dependent, including the provision and maintenance of flood defences, river and catchment modelling, water resources modelling, site inspections and bathing water sampling.

8.22 A key uncertainty surrounding these services relates to the current spending review and the effects that this may have on their ability to deliver their current range and quality in the future. If their capability to deliver them is compromised it is possible that there may be greater pressure on us to deliver some of them or provide funding by way of contributions to defences, increased permit fees or charges for currently free services. Under those circumstances a review of our regulatory regime may be necessary in order to ensure that we are properly funded.

The power sector

8.23 As our treatment processes and support activities (offices, laboratories) are heavily reliant on a dependable power supply the interdependency with the power sector is key to us. Owing to the nature of the power industry there are two types of interdependency:

- the generators - they may be dependent on us for boiler feed water, we may be in competition for river abstraction and they supply power to the grid
- the distribution companies - we rely on them to deliver power to our sites.

8.24 If a power generating station fails, the loss of power is compensated for by the National Grid. They would source power from another station, so we should not see any effect on our processes. Water resources issues can be dealt with in a planned way through the WRMP and national / regional policy-making processes, so again there should not be an immediate effect.

8.25 Problems with distribution have the potential to have a large and immediate effect on many of our activities with little or no notice. Many of our sites have duplicate power supplies or standby generation. This is not standard but they are subject to risk assessments and subsequent business continuity plans.

8.26 We are aware that the electricity distribution companies are working on continuity of supply, but our current level of contact with them on the issue of climate change adaptation is an area for improvement. As a business, where there is a significant risk to our services from power failure, we have overcome this by employing methods such as fixed generation or dual power supplies to add resilience. However improved liaison would help us to make more informed decisions with regards to our adaptation actions and relationships are already being established.

Water companies

8.27 As we are not the only water company to provide services to our region it has been important to examine the interactions across our boundaries. With Cambridge Water and Essex and Suffolk Water we have completed a joint planning exercise to test whether trading or sharing water resources in East Anglia will lead to enhanced customer and environmental benefits.

8.28 The study 'Trading theory for practice' looked at current WRMP in Cambridgeshire, Essex, Suffolk and Norfolk. This is an area that is vulnerable to the effects of climate change, growth and future sustainability reductions in water abstraction and the limited surpluses available mean that investment to maintain the supply / demand balance is needed in the short, medium and long-term.

8.29 The study concluded that the only economic options for sharing or trading resources were already in operation. The challenge of climate change will mean we will need to find more innovative ways to ensure secure water resources in the future. Investment in winter storage in impounding structures or below ground as part of aquifer recharge schemes will also be essential. Investing in strategic storage and transfer capacity beyond 2035 would mean that there would be long-term opportunities to increase the volume of water that is shared or traded.

Taking adaptation forward

8.30 We believe that we can not adapt successfully in isolation and so we will play a leading role in national, regional and local climate change activities by engaging in the debate with key policy and delivery bodies. We intend to build on the already strong relationships that we have with key partners such as Defra, Climate East, EA and LRF. Where we identify new partners we will evolve new relationships as appropriate.

8.31 The way we will drive this is through our new 'love every drop' campaign and manifesto[(2)]. This is our commitment to put water at the heart of a new way of sustainable living. 'love every drop' is about:

- helping people in our region to understand just how precious water really is
- effectively managing the impacts of growth and climate change on our region
- working with everyone who influences water use in our region
- acting today while thinking for the long-term.

8.32 These commitments are at the core of our company and will be implemented through the delivery of the actions detailed within this report and our programme of measures. Our monitoring and review cycles will ensure that the processes in place to deliver them remain flexible and appropriate.

2 Full details can be seen on our company website 'love every drop'

9 Monitoring, evaluation and review

Key messages

1. We have a long history of embedding risk management into our processes.
2. Climate change is integrated into our high level strategies and governance, which we are now working to embed at a business unit level.
3. Our monitoring and review processes provide the flexibility to make appropriate changes and adaptation decisions, in both the long and short term. This aligns with the UKCIP adaptation review process.
4. The delivery and efficacy of our approved adaptation investments will be reported through the annual and five yearly regulatory reporting regimes currently in place.
5. Continuous development of our adaptive capacity is being driven by our programme of measures and monitored and reported internally by the CCSG.

Adaptation: making it business as usual

Governance

9.1 Climate change is not a one-off or stand-alone issue. It is imperative that it becomes part of our normal decision making processes. Good governance is central to any well run organisation and key to ensuring that climate change issues are embedded throughout the business. We have been examining the effects of climate change on our business since 1993. A governance structure has evolved to ensure appropriate ownership of this process. The company's commitment and interaction with climate change is shown in Table 9.1 'Our climate change involvement time line'.

9.2 The ultimate responsibility for managing climate change activity lies with our Management Board. This is instrumental in setting our position on climate change and has ensured that it is embedded in the highest levels of our decision making. Key milestones are the:

- inclusion of climate change, and particularly flood risk, within the company high level risk assessment (2006)
- inclusion of climate change as one of the two key themes in the SDS (2007)
- creation and signing of a 'Climate Change Charter' witnessed by the Secretary of State for the Environment (2009) (see Figure 9.1 'Our Climate Change Charter')
- treatment of climate change as a cross cutting theme throughout our PR09 planning (2007-09).

9.3 This has been accompanied by a parallel process looking at embedding the governance throughout the company. A major step in this direction was the creation of our CCSG in 2010.

Table 9.1 Our climate change involvement time line

1993	1997	1999	2000	2003	2004	2005	2006	2007	2008	2009	2010	2011	Current / future work
Water resources first assessed for climate change impacts	Department of Environment 'Agenda for Action' triggers assessment of water resources for climate change impact	Water Resources Plan (WRP) considered the 1997 assessment, no action necessary	Creation of our Water Efficiency Steering Group	Assessment of water resources for climate change impacts (UKCIP02) - preparation for WRP04	WRP04 includes the impact of climate change on headroom Joined CLG	First adaptation risk assessment Creation of our Energy Steering Group	Climate Change Advisor post created	Published our SDS Signatory to Bali Communiqué Assessment of water resources for climate change impacts (UKCIP02) - preparation for WRMP09 Creation of our Flood Steering Group Internal awareness campaign Contributed to Stern Review	Fluvial and coastal flood risk assessment for PR09 Adaptation of water company drought plans Signatory to Poznan Communiqué SMP engagement Pluvial flood risk project - sewer design for PR09 Study impact of climate change on water quality of reservoirs Contributed to Pitt Review	Signing of the Climate Change Charter Signatory to Copenhagen Communiqué WRMP09 considered the 2007 assessment, no action necessary. To be reviewed with UKCP09 Evaluate potential impact of sea level rise on water resources UKCP09 case study	Creation of our CCSG Begin to deliver AMP5 fluvial and coastal flooding schemes Second adaptation risk assessment Review of WRMP09 with UKCP09 Begin to deliver AMP5 resilience schemes Completion of Wing extension Review Biodiversity Action Plan in light of UKCP09 Signatory to Cancun Communiqué Engagement with BS to create standards for 'rainwater harvesting' and 'grey water reuse' installations Begin to deliver AMP5 demand management (leakage repairs, water efficiency and metering) Influence development of sustainable urban drainage schemes best practice guide Creation of a climate change worksteam in our Innovation Team PhD on climate change, groundwater quality and catchment management Norwich resilience scheme	Adaptation report submission Incorporation of climate change impacts into business continuity plans Engagement in catchment management projects (AMP5 - DWI / WFD) Make climate change an integral part of water supply planning Interdependency assessment Biosolids review Catchment Flood Management Plans Lincolnshire Coastal Plan	Fluvial and coastal flood risk assessment post PR09 and UKCP09 Submission by consortium for EPSRC project on ARCC Climate change impacts on above ground water infrastructure Growth and Water Cycle Studies Integration of climate change adaptation into R and V process Assess impacts of climate change and growth on peak demand Review of company strategy Review flooding incident management UKWIR research into climate change impacts on water and wastewater Engagement in implementation of SMP

Figure 9.1 Our Climate Change Charter

anglianwater leading on climate change

Our region is uniquely affected by climate change. Anglian Water promises to:

- Meet, and where possible, exceed targets for CO_2 reduction
  We are on target to reduce CO_2 emissions by 20 per cent by 2010.
- Substantially reduce our carbon footprint
  Our energy bill has reduced by £7.6 million since 2005/6 with nearly a quarter of our energy now coming from renewable sources.
- Become the most water efficient region in the UK
  Saving water saves energy. At 65 per cent, more of our customers have meters than any other water company. We aim to reduce water consumption to an average of 130 litres per person per day by 2030.
- Work with our suppliers and partners to help achieve our climate change targets
  More than 500 pledges have been made by suppliers, including to measure and reduce emissions; to raise employee awareness around climate change and empower them to take action; and to appoint a Board champion to drive best practice.
- Be innovative and develop even more sustainable ways of working
  Our newly developed carbon calculator brings state-of-the-art technology to the heart of our business, enabling the carbon footprint of all maintenance and construction work to meet, or beat, our target.
- Encourage all employees to reduce their carbon emissions at home and at work
  We have introduced a car-sharing database for personal and business travel; and our 'Why Travel?' initiative has reduced business mileage by 10 per cent.
- Encourage our customers to take action on climate change
  Ofwat recognises us as the industry leader in customer service (2008). We work with our 6 million customers to encourage greater water efficiency, energy saving and reduce their carbon impact.
- Protect and enhance species and habitats across our region
  Our region has more SSSIs than any other in the UK. We are pledged to lead the way in ensuring that our SSSIs are in favourable condition.
- Maintain safe and secure water supplies to help the region adapt to climate change
  Our region is the fastest growing in the UK with millions of homes and jobs dependant on our services. Our planned investment of £2.26 billion to 2015 will help to secure supplies and protect the region from the impacts of climate change.
- Embed climate change mitigation and adaption into decision making processes
  We will use and promote the use of water cycle studies to plan for growth and climate change in our region and continue support the regional Strategic Water partnership.

Jonson Cox
Chief Executive, Anglian Water

In the presence of
The Rt Hon Hilary Benn MP
Secretary of State for Environment, Food and Rural Affairs

Date 5 May 2009

Our Climate Change Steering Group

9.4 Our CCSG reports directly to the Management Board. It consists of senior management representatives from our key business units and five Executive Directors, including the Regulation Director who carries Board responsibility for climate change. This was set up in 2010 to give a coordinated focus on the delivery of climate change activity within the company. Prior to this, climate change actions and issues were dealt with through a number of other steering groups and overseen by the Corporate Responsibility Committee. The CCSG brings together both adaptation and mitigation workstreams and its purpose is to:

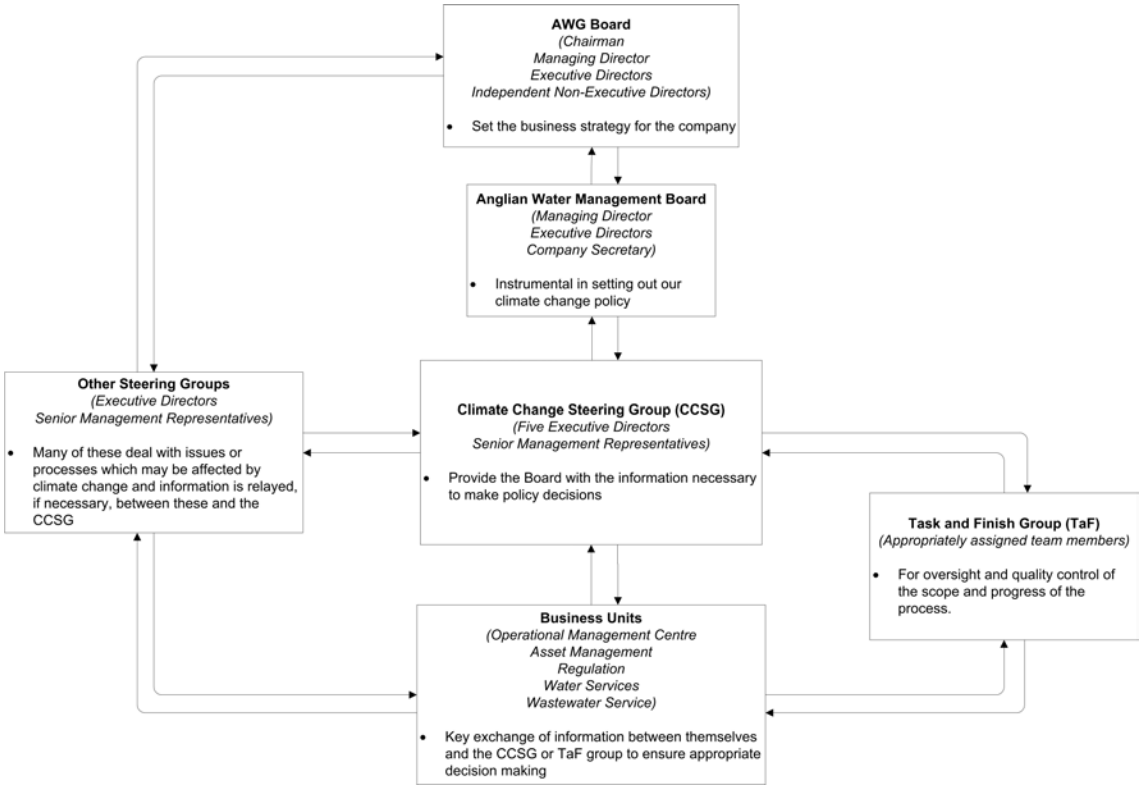
- provide the Board with the information necessary to make policy decisions
- ensure coordinated delivery of climate change mitigation and adaptation actions
- approve and assign actions to members
- provide a monitoring and review process for climate change action.

9.5 Task and Finish (TaF) groups may be assigned to deliver specific actions and can consist of members of the steering group and / or other members from relevant business units.

9.6 Climate change related information is relayed to and from business units and the steering group independently, on request or by routine reports. This two-way process allows coordinated analysis and policy discussion to be carried out. Such an exchange is key to

appropriate decision making and establishing a feedback of information that allows a system of continuous review to be developed (see Figure 9.2 'Our climate change governance structure').

Figure 9.2 Our climate change governance structure



Embedding climate change thinking across the company

9.7 Across the company there is a wide range of other steering groups, many of which deal with issues or processes which may be affected by climate change. When the CCSG deals with issues that may have implications for other such groups, actions or papers are passed to them as necessary.

Flood Steering Group

9.8 The Flood Steering Group was set up in 2007 to reassess our approach to the flood risk associated with our assets. It is chaired by our Director of Wastewater and the Operations Management Centre (OMC) and includes members from business units with activities susceptible to the impact of flooding. Its key roles are to:

- monitor and inform relevant national guidance, ensuring that the long term strategy delivers sustainable flood management strategies
- ensure the effective tactical management of flooding affecting our customers and our assets
- develop management strategies and inform mitigation programmes
- review event responses and mitigation actions and communicate lessons
- ensure our policies and design standards are appropriate and promote changes where needed.

Innovation and the Innovation Review Board

9.9 The Innovation programme is created and managed by the Innovation Review Board (IRB) and the Innovation Client Groups (ICG). The IRB provides strategic direction, general approval of research programme areas and agrees funding, whilst the ICG provide governance at the project level.

9.10 A stagegate process is used for moving a new technology / project from idea to launch. Stagegate divides the effort into distinct stages separated by management decision gates.

- **Business Case** – describes how projects are initially justified for further investigation
- **Initial Feasibility** – describes how projects offering sufficient opportunity / promise are further developed to provide greater detail
- **Pilot Study & Development** – describes how projects that require laboratory or operational trials are devised
- **Exploitation** – recommends actions for Innovation projects that the business wants to adopt, to aid successful roll-out throughout the company at suitable sites / locations
- **Review** – describes how to ensure that all lessons learnt during the project development process are fully captured, especially if the project is to undergo further exploitation into other parts of the business.

9.11 Projects that the IRB has passed as appropriate for investment are allocated to one of the current work streams which are divided into three subject areas: water, wastewater and energy. Historically climate change projects have been carried out within the most appropriate of these workstreams. In this AMP period a dedicated new climate change work stream has been created within the energy subject area to manage adaptation projects.

Water Efficiency Steering Group

9.12 This group was originally created 10 years ago to provide a forum to discuss an annual water efficiency action plan and to involve other areas of the business in the decision making process. The membership includes representatives from business units that feed into water efficiency including Developer Services, Metering, Customer Services, Leakage, Asset Management and Business Customer Services.

9.13 Although the membership has remained the same its focus has since been amended to take into account the changes made necessary by the setting of the mandatory water efficiency target in 2009. In its current format it meets quarterly to discuss progress towards the Water Efficiency Target and to share information on current initiatives and water efficiency projects both for customers and within our own employees and buildings. The outputs of this steering group and its associated activities have a positive effect on our climate change adaptation.

Business Continuity and Emergency Response

9.14 Historically emergency planning and response centred around the use of event specific Business Unit Continuity Plans written by the water and wastewater impact teams as part of our OMC. These were building or asset based and focused on the reinstatement of the whole site or relocating the whole staff as soon as possible.

9.15 Since the creation of the BCER team, the past two years has been spent reviewing existing Business Unit Continuity Plans and converting them to more team-specific Process Recovery Plans. Whilst these are generic and do not relate to any specific scenario they can be used to deal with a whole variety of causes including weather related events. We have switched to this methodology as it allows for a prioritised recovery of processes in order of criticality thereby providing the company with a significantly improved level of resilience.

9.16 Other strands to the strategy have included the:

- expansion of our existing Disaster Recovery Centre
- development of a second Disaster Recovery Centre
- creation of Flood Emergency Response Plans for key sites
- development of the First Reserve program to mobilise additional volunteer manpower for unplanned events
- accreditation to BS25999 - Business Continuity (see Case Study 1).

9.17 Outside of direct Business Continuity activities, the Emergency Planners within the BCER team sit on a number of external multi-agency groups. They assist with drawing up Multi-Agency Flood Plans across LRF in the region. They also actively plan and participate in exercises, many of which are linked to weather events, and maintain ongoing links with the EA and Meteorological Office. Through these links they receive briefings on new products and services such as the Flood Forecasting Centre, amendments to the EA Flood Warning Codes, and the on-line Hazard Manager Weather system.

Corporate Responsibility

9.18 Historically Corporate Responsibility (CR) has been delivered by a steering group in a similar manner to the CCSG. However CR is core to how we do business incorporating many of the subject areas covered by other steering groups, so it is now managed directly by the Management Board. Feeding information into this is the CR working group, with membership representing all parts of the organisation.

Incorporating climate change into our performance assessment, monitoring and reporting

9.19 To manage our operations effectively we already monitor, assess and report on the performance of our assets. These activities are also key to understanding and tracking the effects of the current climate on our assets so that we can plan adaptation action accordingly. The following section is an overview of how our monitoring, evaluation and review cycle operates, how it already includes adaptive capacity and any changes that we intend to make to better integrate climate change.

Creating and monitoring our assets

9.20 The monitoring of our water and wastewater asset performance is carried out by a combination of two methods:

- direct monitoring and recording of their operation by one of the largest telemetry networks in Europe
- a region-wide sampling regime of the inputs and outputs of our WTW and WwTW.

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Monitoring, evaluation and review

9.21 Our telemetry network operates twenty four hours a day and collects information necessary for us to monitor the performance of our assets and intervene if necessary. This can include information as diverse as sewage levels in tanks, whether a discharge is operating or whether a particular piece of machinery is running or out of service. All of this data is collected by our OMC which then uses it to:

- coordinate real time interventions, such as turning on pumps remotely
- schedule repairs and maintenance
- carry out, in conjunction with other teams, analysis of the performance trends.

9.22 In parallel to the telemetry system our Regulation business unit runs a sampling programme which allows us to analyse and monitor the outputs of our water and wastewater treatment works. This is used in conjunction with the telemetry data to analyse the performance trends of our assets, in particular for compliance with any relevant water quality standards as set by our regulators.

9.23 A third team which uses both sets of data to analyse asset performance is Asset Planning. This team focuses on identifying longer term trends which may lead to a requirement for further investigation or investment.

9.24 A number of internal focus groups also use this data to ensure that the trends inform decision making to maintain or improve asset performance. Outputs from these groups takes the form of three main workstreams:

- immediate small-scale maintenance or asset creation necessary to mitigate urgent or minor problems
- more significant and / or longer term solutions to deal with existing or developing issues
- strategic planning.

9.25 The first of these is delivered directly by asset 'owners' on an urgent 'local' need basis, however due to their more strategic nature the other two are subject to a number of further decision informing processes.

9.26 Items in the second workstream enter our CDP. This uses a robust series of challenges to examine the need and any solution arising to ensure that it is appropriate. Depending on the scale of the final solution, proposed delivery will be by either our major construction or local construction partners. Greater detail on the CDP can be found later in this section.

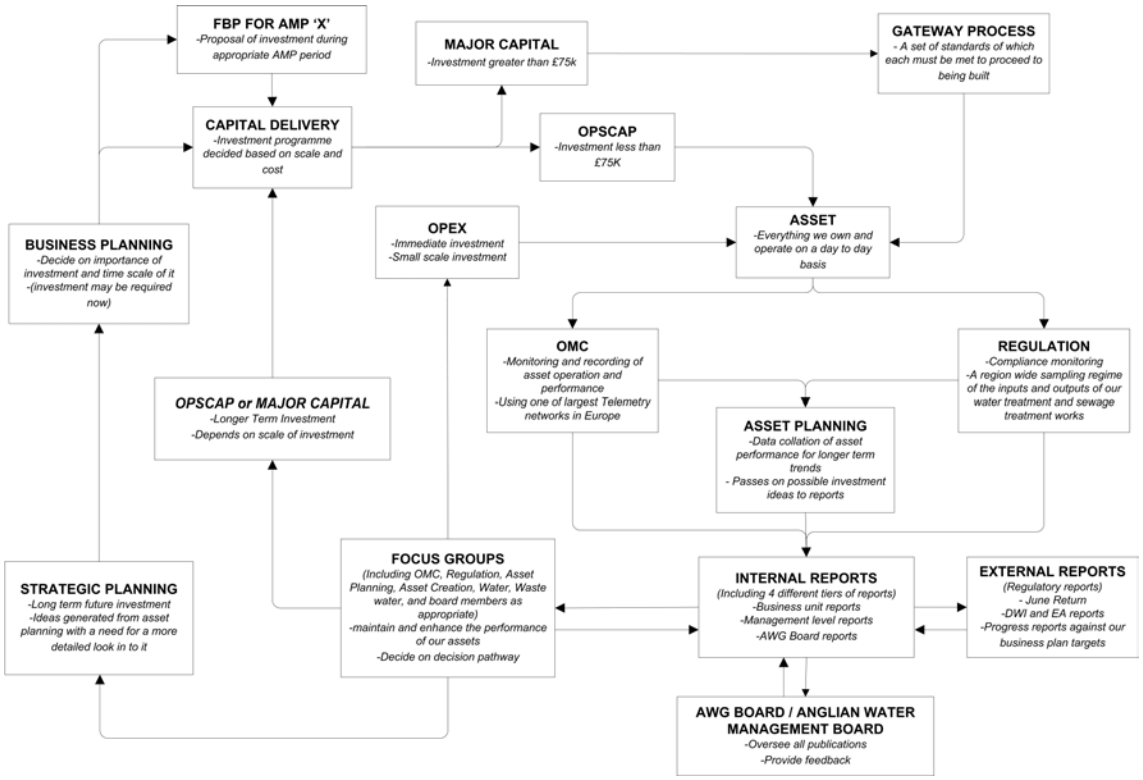
9.27 The strategic planning work stream would be carried out by a combination of our Asset Planning and Strategic Asset Management teams. This workstream concentrates on identifying medium and long term future investment scenarios. The work will look at existing and long term trends in asset performance, upcoming regulatory changes or other possible changes which may require investment in our assets. This data, along with other inputs, is used to forecast possible future performance and the operational or capital expenditure which may be necessary to maintain compliance and level of service.

9.28 If this indicates that urgent work is necessary the results will be fed straight into the CDP. Such work may be self-funded or fed back through the regulatory regime as a notified item, via the logging up process or for an interim determination of our funding if it is sufficiently large.

9.29 Results that indicate a non-urgent investment need will be fed into the Business Plan submission process for the most appropriate AMP period depending on the scale and timescale of any investment need. Any work approved by Ofwat as a result of the business planning process will then be put through the CDP.

9.30 When a new asset is created appropriate telemetry is included as are the relevant sampling regimes. In some respects it could therefore be suggested that this is the starting point of our asset monitoring and review system. In actuality the system is a cycle which can be started at any point (see Figure 9.3 'Our monitoring and review cycle').

Figure 9.3 Our monitoring and review cycle



9.31 The cyclical nature of this system ensures that changes in asset performance, compliance or regulatory requirements can be captured and reviewed as soon as they occur. It also means that the state of our assets and our knowledge about them is not static and is subject to continuous scrutiny and review. The final advantage of such a system is that it can be reviewed as a whole or in its component parts as necessary, thereby giving the system flexibility to adapt as necessary.

Capital delivery and adaptation

9.32 In tandem with the Strategic Planning route, the CDP has the largest capacity to deliver or hinder adaptation actions. Therefore the following paragraphs give a high level breakdown of this element of the Asset Creation and Monitoring cycle to demonstrate how it works and the degree to which adaptation is or can be incorporated.

Flexibility of the process

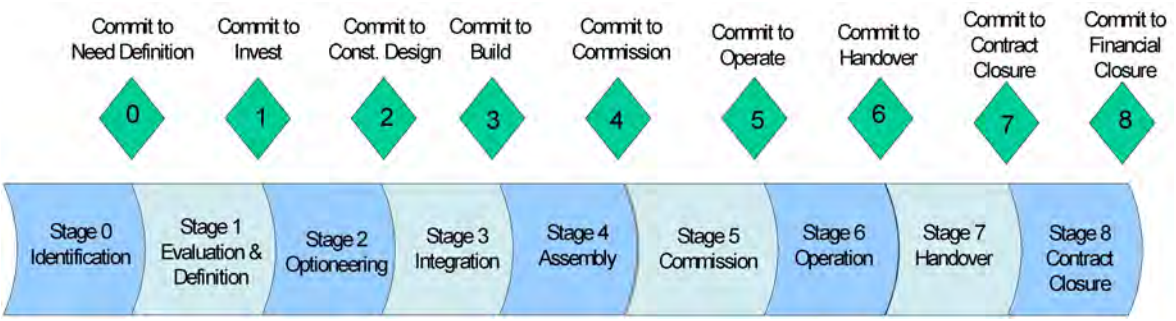
9.33 The current CDP was developed at the end of AMP4. Whilst its deployment across the capital programme is mandatory, it is continually reviewed and refined. Its structure is designed to be adaptable and able to incorporate external drivers. It already contains whole

life cost, energy and carbon parameters which can be adjusted to reflect revised targets for capital solutions. The current format is the 'Anglian Water AMP5 Common Capital Delivery Process' and its purpose is to be:

- a single end to end common delivery process with clear ownership and accountability
- for use on all types of projects whichever part of the asset creation process delivers them.

9.34 It is a gateway driven process where projects can only pass from one stage to the next if all challenges and requirements at the appropriate gateway have been met (see Figure 9.4 'The gateways'). Any policy or target changes can be quickly and uniformly applied to all projects passing through the process by changing the requirements at the appropriate gateway. This brings a rigour and consistency to all projects whilst allowing the process to be extremely flexible.

Figure 9.4 The gateways



9.35 Within this process a number of tools and activities provide technical input and a framework for decision making to ensure the implementation of the process and gateway requirements. Two of the most significant ones are:

- the R and V process
- optioneering and detailed design.

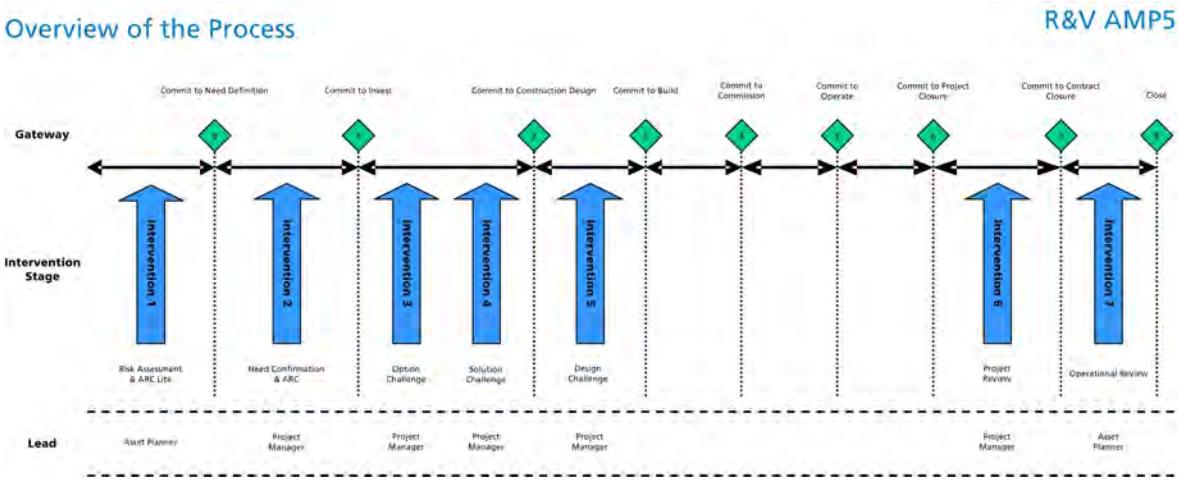
Risk and Value

9.36 This is a parallel process which challenges the decisions made as a solution passes through the CDP to ensure the optimum balance between performance, risk, cost and time. It links into the CDP through seven key interventions as shown in Figure 9.5 'The R and V process'.

9.37 At each intervention all project decisions and assumptions are challenged to test their validity and to ensure the appropriateness of the solution proposed. Key components of the interventions include stakeholder engagement, use of common minimum asset standards, economic risk analysis and the running of event risk scenarios. These challenge our investment, our understanding of acceptable risk, the way we manage risk and how we do things from design and construction to operation.

9.38 Experts in the appropriate fields are brought together to collaborate on the delivery of projects or the ongoing operation of our assets. This stakeholder engagement endeavours to ensure that we understand, and have realistic expectations of, operational and capital investment.

Figure 9.5 The R and V process



9.39 Our economic risk analysis uses an industry-leading methodology that financially values the risk of service failure from our assets. It forms part of the challenge by examining the link between risk and the financial cost of the assumptions within the various solutions available. For example, is a given solution:

- cost beneficial?
- acceptable in terms of residual risk?
- least whole life cost?
- affordable?

9.40 Although they are used as part of the R and V challenge process, the use of minimum asset standards and future risk scenarios predominantly occurs within the optioneering and design phases of the CDP.

Optioneering and design

9.41 In the stages covered by these activities (stages two and three) the tools detailed above are used to evaluate as many solutions, that may meet the business needs, as possible. This allows us to make quantitative judgements on cost, value, and risk reduction to aid solution selection and development.

9.42 Stages two and three require design assumptions and design parameters to be defined. At this point all variables that may affect design are incorporated. Key to this is the running of future event scenarios for parameters that may affect asset design. Examples are:

- flood risk - in general the current design level of protection provided for fluvial and coastal flooding for major assets is 1 in 100 years. For resilience schemes we have increased this to 1 in 200
- rainfall intensity - Meteorological Office modelling suggests that in 2080 a 1 in 30 year rainfall event will correspond to todays 1 in 50 year events. Our normal design standard for sewers is to prevent flooding from rainfall intensity of up to 1 in 30 years. In order to maintain this, the capacity of sewer systems may need to be reviewed

- temperature effect on process design - we compare the range of biological and chemical process performance against the seasonal average temperatures to ensure that a design would meet the required compliance standards
- site power supply - including security of supply (climate related or not) and energy efficiency
- carbon targets - to halve our embodied carbon emissions of assets we build in 2015, against a 2010 baseline and reduce our operational carbon emissions by 10%, in real terms, by 2015 from a 2010 baseline.

9.43 A core philosophy of AMP5 will be the use of products complying with minimum asset standards to ensure we minimise redesign and optimise the opportunities for using best practice. The parameters set for these standards can be reviewed and changed as additional knowledge regarding the demands on assets becomes available. These are core building blocks in the process of standardising what we do and also mitigating over-engineering.

The future incorporation of climate change in the CDP

9.44 Where an asset is created as a result of a specific climate change adaptation driver, the full impacts of climate change will already have been taken into account before it enters the CDP process. Our programme of measures includes an action to review the CDP to ensure that all projects passing through it are subject to the same rigour.

Reporting

9.45 Data and other information on our company actions is collated and analysed throughout the business on many systems, however its reporting is tiered in a defined manner as follows:

- level one reports are created for the Board of our parent company AWG and are used for monitoring our company performance. However many of them are also regulatory requirements or data sources for other external reports
- level two reports are created for our Management Board and serve the same purpose as level one reports
- level three reports are created by business units to monitor their own, or their assets', performance. These are created for the business unit director and are sources for level one and two reports
- level four reports are any created within individual teams or business units. They are used for internally monitoring their own, or their assets', performance and may be used as sources for level three reports.

9.46 This structure ensures that data flows through the right analytical and decision making processes and where appropriate is reported to the relevant decision makers.

9.47 Although data flows between the reporting levels appear linear, from four up to one, the whole system does have a feedback process built into it. This ensures that information can pass between all levels in both directions. This can be seen in Figure 9.3 'Our monitoring and review cycle' where a number of feedback processes can be seen into the 'internal reports' box. This is in addition to the wider feedback provided by our regulators.

9.48 One of the key purposes of the various steering groups, focus groups and review boards, including those detailed in the section above, is to coordinate the collation, analysis and dissemination of the data and information. This ensures that the reports (internal and

external) are accurate and that our performance and the procedures and policies driving it are reviewed. It also allows issues arising to be discussed in the appropriate forum leading to the dissemination of actions where necessary.

9.49 Another role of the groups is to look at the wider picture of our performance in relation to our liaison with other stakeholders. Table 9.2 'Key reports and liaison groups' gives brief details of some of the key external reports and liaison groups which incorporate and / or deal with climate change.

Table 9.2 Key reports and liaison groups

Report/group	Description	Frequency
Annual Report and Accounts	Statutory report - external	Annually
Drinking Water Quality Report	Statutory report - external	Annually
Community and Environment Report	Statutory / voluntary report - external	Annually
SDS	Statutory report - external	Five yearly
WRMP	Statutory plan - external	Five yearly
Drought Plan	Statutory plan - external	Three yearly
June Return	Statutory report - external	Annually
Climate Change Adaptation Report	Statutory report - external	As directed
County Council Climate Change Steering Groups	Local liaison	Periodically
LRF	Local liaison	Periodically

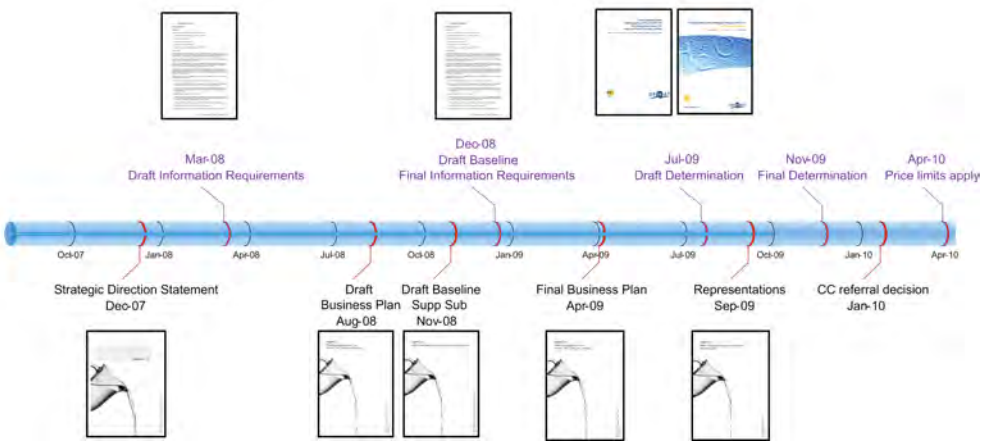
Other review cycles

The Periodic Review

9.50 Since the privatisation of the water industry in 1989, Ofwat has been responsible for determining the level of funding and investment by the water companies in England and Wales. This process is a five year cycle called the Periodic Review (PR) and each iteration results in a business plan that each company takes forward in the form of an AMP. The current review was determined in 2009 (PR09) and has produced AMP5 for delivery in 2010 - 2015.

9.51 Through our routine operations, regulatory liaison and business planning activities we constantly monitor the performance of our assets and the regulatory environment within which we operate. As a result of this we develop an understanding of any new or ongoing investment that we will be required to make in order meet our regulatory and customer service requirements. The creation and submission of the DBP to Ofwat is the first stage in the periodic review process as shown in Figure 9.6 'PR09 time line'.

Figure 9.6 PR09 time line



9.52 Ofwat examines the DBP in relation to the justification for the investments included and compares it and the other companies' submissions to a series of cross-company comparators in order to gauge the relative performance of each company. Ofwat then responds to each company with comments, which we review against our DBP. In due course our FBP, amended as necessary, is submitted to Ofwat.

9.53 The FBP is scrutinised by Ofwat in the same manner as the DBP and it issues a Draft Determination approving, querying, challenging or rejecting items within the FBP. From this we make representations to Ofwat as appropriate in order to influence their position. Finally Ofwat produces the FD which sets the programme of investments.

The Water Resources Management Plan

9.54 The WRMP is also subject to a full review on a five year cycle which is currently out of phase with the Periodic Review. The review is carried out in liaison with the EA and Defra. Although its next full review is due in 2015 it is also subject to an annual review with the EA and periodic internal reviews. An example of an internal review, using newly available climate projections, is shown in Case Study 8.

9.55 In the most recent review a new statutory process for delivering the WRMP has been used during which we consulted a wider audience on the plan. These were published in our Statement of Response to representations received in February 2009. We further revised our WRMP to take into account Defra's request for further information and published our Supplementary Statement of Response in September 2009. Defra then gave us permission to publish in December 2009 and formally signed it off in February 2010.

Drought plans

9.56 All water companies are required by the Water Industry Act, as amended by the Water Act 2003, to produce a Drought Plan in consultation with the EA. We consulted on the Draft Drought Plan in 2006 and, after making changes required by Defra, published our Drought Plan in July 2008. We keep our Drought Plan under review for any material changes and will prepare and submit a revised Drought Plan to the Secretary of State at Defra, as required.

Case Study 8

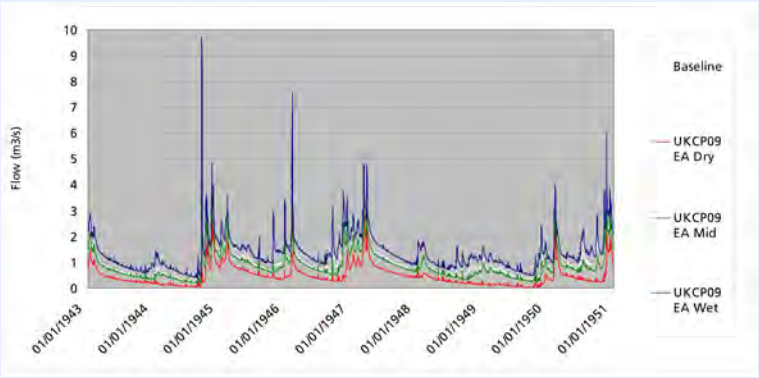
The UKCP09 review for our surface water sources

The UKCP09 projections provide greater spatial and temporal detail and more information on uncertainty than UKCIP02. To build on previous work the 'lintegrated_Spreadsheet_v3.0' developed by the UKWIR06 'rapid review' project was used with the new medium emissions scenario precipitation and potential evapotranspiration projections for the 2020s. Further work was then done using the UKWIR06 tool and the UKCP09 climate scenario calculation methodology.

Although similar to the UKWIR06 outputs, the UKCP09 scenarios for our region predict drier winters, wetter summers (mid and wet scenarios) and wetter springs (dry scenario). Across all emission scenarios potential evapotranspiration is projected to increase in the dry and mid scenarios, particularly the summer and late autumn / early winter months, and decrease in the wet scenario summer months.

These data were used to provide updated surface water asset yield and deployable output projections for three of our reservoirs and one direct supply river intake. It showed lower yields at the sources for dry and mid scenarios than in baseline (no climate change) and UKWIR06 scenarios. The wet scenario projected higher yields. Reservoir yields for dry and mid UKCP09 scenarios gave a 2-3 Ml/d loss, while the wet scenario gave a 1-2 Ml/d increase. All yields are further from the baseline than for the UKWIR06 scenarios. The UKCP09 dry scenario gave a net yield of 0 Ml/d at the direct intake compared to 1.9Ml/d for UKWIR06. This is due to the simulated minimum river flow being below its Minimum Residual Flow.

Figure 9.7 Hydrograph of simulated river flow for the direct supply intake



DO is limited by factors such as abstraction licences and WTW capacity, so climate change has a smaller range of impact. The greatest change is for the dry scenario with a projected reduction of 13 to 43% at all sites. The direct intake site was shown to be more susceptible than the reservoir sites, in terms of % yield change from the baseline (See Hydrograph of simulated river flow for the direct supply intake).

This work shows that the UKCP09 mid and wet scenarios give similar DO to UKCIP02, however dry scenario DO are more extreme. As these changes do not have significant impacts in the near term we agreed with the EA that we would not seek an IDoK at this time. We will wait for EA / UKWIR project outputs which will provide industry standard guidance for integrating climate change into the next WRMP process.

9.57 The EA has worked with Defra, the Welsh Assembly Government, the water industry and other consultees to replace the previous guidelines published in October 2005. The main areas to be updated are environmental monitoring, drought orders / permits and the new temporary use ban provision in the Floods and Water Management Act 2010. We have responded to the EA draft drought plan guideline consultation in 2010 and expect the final guidelines in January 2011.

9.58 The process of preparing and publishing drought plans is similar to the WRMP process. A period of consultation is required, followed by a statement of response and then publication of a final drought plan after Ministerial direction. We will start reviewing our drought plan within three years of the publication date of our previous final plan, this will commence from January 2011. We will have six months from this date to prepare our draft drought plan and submit it to Government.

The need to be flexible

9.59 The governance for managing climate change is now embedded and designed to enable us to review our risk assessment on a periodic basis. We can respond quickly to any changes associated with the development of new data sources, legislation or opportunities.

9.60 Our monitoring systems focus on asset performance which is aligned with our risk assessment and management activities. We have concluded that monitoring the assets' performance will show their response to climate change through trend and root cause analysis. We believe that this method, coupled with the scenario modelling, will allow us to identify critical thresholds and to track climate influenced trends. We will therefore be able to plan solutions and design standard changes in advance of their need.

9.61 Climate change data are used within our climate change adaptation projects generated through our Asset Planning process and delivered by Asset Management. Through the work of the CCSG and the associated steering groups we aim to ensure that this becomes fully embedded in all of our decision making processes in preparation for the next periodic review.

9.62 In line with adaptation best practice, we recognise we must maintain flexibility in delivering adaptation action. We will therefore continue to identify new risks and actions through our review process. The review of our business plans, through the periodic review process coupled with the longer term strategic view in our SDS, ensures that adaptation is given focus over both the long and short terms. We see the AMP cycles as the key mechanism for delivering any adaptation actions that are identified.

10 Opportunities

Key messages

1. Owing to the regulatory nature of our business there are limited opportunities.
2. Those opportunities identified have come via our risk assessment activities and we expect this to continue.
3. Our biggest opportunity is closer engagement with all of our stakeholders, especially customers, to deliver positive behavioural change.
4. Our governance allows us to identify and act on these opportunities when they arise.

Can we take advantage of climate change?

10.1 The process of examining the risks to our business has enabled us to identify that climate change is not just a series of problems and threats. We have established that a number of the challenges, or the way in which we could deal with them, may provide opportunities.

10.2 The generation of this report has been a positive opportunity. It has given us a framework to carry out a timely audit of our climate change adaptation progress to date. Through it we have tested our risk assessment methodology as well as our governance, communication and review processes and channels.

10.3 As a result we have been able to generate a programme of measures which sets out what we have delivered, are delivering and planning to deliver, to further ensure our sustainable adaptation. In order to address many of our actions we and our other stakeholders will need greater cooperation. This could be heightened by future potential changes in the funding of our regulators and other parties, leading to a shifting of regulatory burdens. We are already seeing a desire for this in flood strategy and management, particularly led by the local authorities and the EA. Cooperation could lead to efficiencies such as:

- greater coordination and communication on common research goals
- cofunding of multi-stakeholder and multi beneficial adaptation actions
- identification of as yet unconsidered opportunities, as a result of the above.

10.4 Alongside our regulators, our customers represent our biggest single group of stakeholders. As they can influence our business in many ways a major opportunity lies in improving our relationship with them. The way we will drive this is through our 'love every drop' campaign and manifesto. This is our commitment to put water at the heart of a new way of sustainable living and is about helping people understand the realities of water use and climate change in our region. More engaged and informed customers will be better placed to assist us in delivering our adaptation actions through their direct action on water efficiency and their role in defining our investment plans.

10.5 Increasing temperatures and sunshine hours could pose potential problems for us relating to workforce welfare and may challenge the efficiency of some of our biological WwTW processes, however they may also introduce opportunities. For example:

- warmer average temperatures could raise the efficiency of some processes giving better and faster treatment
- we may be able to take advantage of a wider range of existing or new treatment processes
- we could see an increase in the use of our recreation sites.

10.6 The warmer winter temperatures would also mean fewer frost days leading to a reduction in the number of asset breakdowns due to frozen pipes and valves.

10.7 At WTW it is easier to treat a given volume of water in the summer as higher temperatures causes the water to become less dense. This speeds up certain parts of our water treatment processes, in particular those associated with filtering and settlement. Although this is slightly counteracted by a need to backwash our filters more often, owing to increased algal growth in raw water, we are still able to process greater volumes.

10.8 As warmer weather already tends to lead to increased demand by our customers climate change could serve to exacerbate this. However the rise in public awareness of the potential effects of climate change may lead to behaviour change in consumers, such as has been seen in drought stricken areas of Australia. This opportunity is a key message of our 'love every drop' campaign. This is about changing our customers' perception of the valuable water resource available to us, the role it plays in a thriving East of England and its increasing scarcity.

10.9 The changes in rainfall patterns with a shift to wetter winters and drier summers initially seems to be an obvious challenge for our water resource position, however it does present a number of other opportunities:

- improved bacteriological quality at bathing waters owing to more sunshine hours, giving increased natural UV disinfection, combined with reduced storm flows in the summer
- increased abstraction into storage reservoirs in the winter months owing to greater river flows. With appropriate capacity this would help deal with the summer demand increases and reduced summer rainfall
- an investigation into changes in our leakage and burst strategies, in response to future rainfall and temperature patterns altering the profile of burst occurrences in our water and sewerage pipes.

10.10 One significant area of the business where we have not yet been able to identify what opportunities climate change may pose, is that dealing with biosolids. This is because these activities are dependent upon two areas that are themselves subject to large uncertainties. Firstly the raw product comes from our wastewater operations and it may be affected in several ways by climate change. Secondly there is large uncertainty over how its customer, the agricultural sector, will react to climate change. Also there are a number of regulatory uncertainties which may heavily influence its future.

10.11 The high level of uncertainty in both its input and output routes has made a detailed analysis of its opportunities and threats too complex to complete within the timescale of this report. Case Study 9 gives a high level overview of the risks arising from climate change

and possible benefits identified for investigation. These have been included in our list of barriers, assumptions, uncertainties and interdependencies. A detailed business strategy review is underway and has been placed in our programme of measures.

Case Study 9

The Biosolids review

Climate change may affect our biosolids operations through changes in the feedstock or impacts on the treatment and recycling activities. Examples of the former include changes in customer water use altering the nature of wastewater to be treated, digesters becoming more efficient at higher temperatures or higher summer temperatures, increasing the risk of breaching Hazard Analysis Critical Control Points compliance upper limits.

Floods pose a significant risk and it is likely that major flood events would need extra resources to maintain normal operations. A flooded STC could cause increased haulage costs to, and operational burdens on, alternative STC. An operational WwTW with flooded access would continue to produce sludge with no outlet, so increasing stock management issues and costs. Flooding at outlet sites could lead to a raised risk of pollution incidents from winter stockpiles or lack of stockpile locations. Where possible flood risk maps and local land drain knowledge will be incorporated into mapping databases and decision processes to reduce these risks.

Higher temperatures could increase odours and bioaerosols necessitating additional controls to mitigate them at STC, outlets and in transit. However a reduced frequency of sub-zero temperatures give cost benefit though a reduction in maintenance and frost damage costs for equipment, vehicles and valves. Biosolids and sludge transportation activities could be affected by the same impacts.

Agriculture in our region is likely to see significant climate led changes and as our main biosolids outlet we need to understand the possible impacts. Warmer drier summers, wetter winters and changes in season timings could put pressure on spreading timetables. Alternatively the agricultural land bank could expand if changes in rainfall pattern led to a shift from water-dependent salad crops to cereals or biofuels. Research into the resilience of the agricultural outlet and other avenues of recycling, such as biofuel production and co-composting will be undertaken.

Figure 10.1 Biosolids recycling

In order to fully understand the impacts and opportunities that climate change will present, a full review of our biosolids activities and strategies will incorporate them. Given the uncertain future it is possible that this review could reveal that the greatest opportunities are to power generation and innovation in alternative biosolids usage.

Looking forward

10.12 Although there are a number of potential opportunities they are mostly serendipitous benefits, rather than true opportunities for us to exploit. Many are conditional on assumptions in the way that climate change will occur and affect our operations and will, as with all aspects of our climate change strategy, need to be kept under review.

10.13 Our climate change adaptation delivery is going to require a significant amount of research work. Pursuing this will be one of the key roles of the new innovation climate change workstream. Through this and their role in the CCSG they will ensure we are able to identify new opportunities and, where they exist, act upon them.

11 Concluding remarks

Key messages

1. We believe that we understand the adaptation needs of our business and that we can deliver these through an appropriate periodic review and AMP mechanism.
2. The continued support from organisations such as UKCIP in interpreting the climate data is critical.
3. Concerted action must be taken to ensure that adaptation actions are taken in a coordinated way and funded appropriately, particularly for critical infrastructure.
4. We will play our part in delivering a successfully adapted UK.

Participation in this first cycle of the reporting power

11.1 Adaptation to a changing climate has been at the top of our agenda since 2005. Our current regulatory framework means that identifying risks, such as climate change, along with delivering, monitoring and reviewing related actions is part of our business model.

11.2 We believe that the new requirement to report on adaptation has come at a very opportune time for our industry, at the beginning of a new investment cycle and soon after the release of the UKCP09 projections.

11.3 Reviewing our approach to risk by using the best available scientific data and most up to date climate projections, allows us to reevaluate known risks and identify new ones for further investigation. Doing this at the beginning of a new AMP period means that business cases for any new actions can be developed in the early stages of the planning cycle.

11.4 One of the strongest conclusions that we have come to in developing our approach to adaptation is that the provision of credible data and projections is extremely important in enabling us to understand the risks to our business. The guidance and technical support that UKCIP has provided to help incorporate this into our internal risk tool and decision making processes has been invaluable. If we expect all sectors of society to make climate change second nature in their decision making then this type of support must continue in some form into the future.

11.5 Looking within our business, developing this report has allowed us to identify a number of other priorities that we have acted on to strengthen our management of adaptation. These have included:

- improving the company governance through the creation of a dedicated CCSG
- identifying critical posts within each business unit which are key to the delivery of successful adaptation
- the movement of substantial elements of our risk assessment onto a quantitative footing. This has validated many of our past actions and lead to some new conclusions for further study
- generating a greater understanding of the importance of interdependencies in managing region wide adaptation.

11.6 Our main conclusion having completed this report is that we feel that the appropriate periodic review and AMP mechanisms will allow us to assess, prioritise, deliver adaptation, review and report in a way that embeds adaptation into our current business planning process. Our regulatory returns and our Annual Report and Accounts (complemented by SDS and Community and Environment reports) will provide our regulators and stakeholders with a comprehensive assessment of our adaptation approach and status. We believe that this will be the most efficient process through which to continue to assess climate change risk and deliver a successfully adapted company.

11.7 An agreement on how adaptation requirements will be assessed in the next periodic review is a priority that we, the industry and Ofwat recognise. This will need to be explored as soon as the adaptation reports are submitted. An early understanding on all sides of how adaptation can be delivered through the current regulatory framework is key to successfully delivering adaptation actions from 2015 onwards.

Moving beyond the reporting power

11.8 The true value of these reports lies in the capacity for their outputs to drive positive change in the delivery of a sustainably adapted UK. Many of the solutions will require cooperation not only between reporting authorities, but also between stakeholders who are not reporting. It is vital to ensure that planning for adaptation runs across sector and political boundaries. For example, in our region the balance to be struck in the management of water between the environment, agriculture and our customers' needs is critical to the region's success. The strategic and coordinated management of the coast in response to rising sea levels is another priority issue.

11.9 How these adaptation reports feed into the national and regional risk assessments and adaptation programmes is critical. This has to include information from those sectors who are not reporting, such as agriculture, or reporting in other ways, such as local authorities. Without this inclusive approach adaptation will be neither sustainable nor successful.

11.10 We hope that concerted action will be taken to ensure that adaptation is given the priority it requires. In order for this to be delivered there are a number of areas that we believe are priorities:

- there must be clear and firm national policy guidance on adapting to inevitable climate change. This must enable local and regional action to be delivered by those recognised with the responsibility and expertise
- ensuring that critical infrastructure and services are robustly but flexibly adapted to climate change. We would suggest that a specific focus should be placed on this at the national level. This should bring together leaders of the relevant sectors to feed directly into the National Adaptation Programme and we would welcome the opportunity to be a part of such a group
- there must be clarity on how the Comprehensive Spending Review (and any future reviews) will impact on the nation's ability to adapt, where this will lead to changes to the responsibility for funding and delivering that adaptation and how this impacts our ability to contribute to this adaptation.

11.11 We understand that to maintain the success of our business and the region we must ensure that the impacts of climate change do not prevent us from delivering the level of environmental stewardship and quality of service that is expected by our customers. This

can be achieved successfully only if all those parties involved pool their knowledge and show a joint commitment to act decisively. Delivering this can be as simple as coordinating our communication campaigns to deliver a more effective behavioural response from joint stakeholders, through to active engagement at a national critical infrastructure advisory group.

11.12 We have taken the implications of climate change extremely seriously and believe that we know what is required to adapt our business to the challenges. We have ensured that our management structure and planning processes have incorporated adaptation accordingly.

11.13 Climate change is a challenge that we can hope to meet only in unison and we make our commitment to contribute to creating a successfully adapted UK.

12 Glossary

Abbreviations and Acronyms	
AWG	Anglian Water Group
AMP	Asset Management Plan
AMP4	Asset Management Plan 4 (2005 - 2010)
AMP5	Asset Management Plan 5 (2010 - 2015)
AMP6	Asset Management Plan 6 (2015 - 2020)
BCER	Business Continuity and Emergency Response
BIM	Business Impact Matrices
BS 25999	British Standard for Business Continuity Management
CBA	Cost Benefit Analysis
CCSG	Climate Change Steering Group
CCW	Consumer Council for Water
CDP	Capital Delivery Process
CLG	Corporate Leaders Group
Coastal flooding	Flooding from the sea
CR	Corporate Responsibility
DBP	Draft Business Plan
DECC	Department of Energy and Climate Change
Department of Environment	Now known as DEFRA
DEFRA	Department for Environment, Food and Rural Affairs
DG5 risk register	Register of properties at risk from sewer flooding
DO	Deployable Output
DWI	Drinking Water Inspectorate
EA	Environment Agency
EEDA	East of England Development Agency
ESPRC	Engineering and Physical Sciences Research Council
EU	European Union
EUREAU	Industry body representing those involved within the European water and wastewater industries
FBP	Final Business Plan
FD - Final Determination	The conclusion to Ofwat's deliberations regarding our business plan submissions for the given AMP period. This is the document that sets our price review and investment programmes.

Abbreviations and Acronyms	
Fluvial flooding	Flooding from rivers
FSR	Flood Studies Report
GAC	Granular Activated Carbon
Go-East	Government office for the East of England
IDB	Internal Drainage Board
ICG	Innovation Client Groups
IDoK	Interim Determination of K
IRB	Innovation Review Board
LRF	Local Resilience Forum
MISER	Water resources planning and management tool
MWH	Consultancy
NE	Natural England
NGO	Non-Governmental Organisation
OMC	Operations Management Centre
OSAY	Water source yield calculator
Pluvial flooding	Localised flooding caused by surface water from rainfall events. This is not as a result flooding from rivers.
Propex	Additional, temporary operational expenditure
PR	Periodic Review. Five yearly price review for the water industry.
PR09	Periodic Review 2009
PR14	Periodic Review 2014
PZ - Planning Zone	Water resources planning zone
R and V	Risk and Value
Ruthamford	Integrated system of Rutland, Grafham, Pitsford, Hollowell and Ravensthorpe reservoirs
SCM	Supply Chain Management
SDS	Strategic Direction Statement
SELL	Sustainable Economic Level of Leakage
SELWE	Sustainable Economic Level of Water Efficiency
SMP	Shoreline Management Plan
SPS	Sewage Pumping Station
SSSI	Site of Special Scientific Interest
STC	Sludge Treatment Centre
TaF	Task and Finish

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Glossary

Abbreviations and Acronyms	
UKCIP	UK Climate Impacts Programme
UKCIP02	UK Climate Impacts Programme projections 2002
UKCP09	UK Climate Impacts Programme projections 2009
UKWIR	UK Water Industry Research Ltd
UKWIR06	UKWIR methodology 2006 developed from UKWIRCL04
UKWIRCL04	UKWIR project - Effects of climate change on river flows and groundwater recharge; guidelines for resource assessment and UKWIR06 scenarios.
UV	Ultra Violet
WA	Water Abstraction
Water UK	Industry body representing the water and wastewater utilities in the UK
WBS	Water Boosting Site
WESG	Water Efficiency Steering Group
WFD	Water Framework Directive
WRMP	Water Resources Management Plan
WRMP09	Water Resources Management Plan 2009
WRMP10	Water Resources Management Plan 2010
WRMP14	Water Resources Management Plan 2014
WRP	Water Resources Plan
WRP04	Water Resources Plan 2004
WRZ	Water Resource Zone
WTP	Willingness To Pay
WTW	Water Treatment Works
WwTW	Wastewater Treatment Works

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Corporate Communications
Anglian Water Services Ltd
Anglian House, Ambury Road
Huntingdon, Cambridgeshire
PE29 3NZ

Tel 08457 919155
Fax 01480 323112
Email: regulation@anglianwater.co.uk

Registered in England No. 2366656